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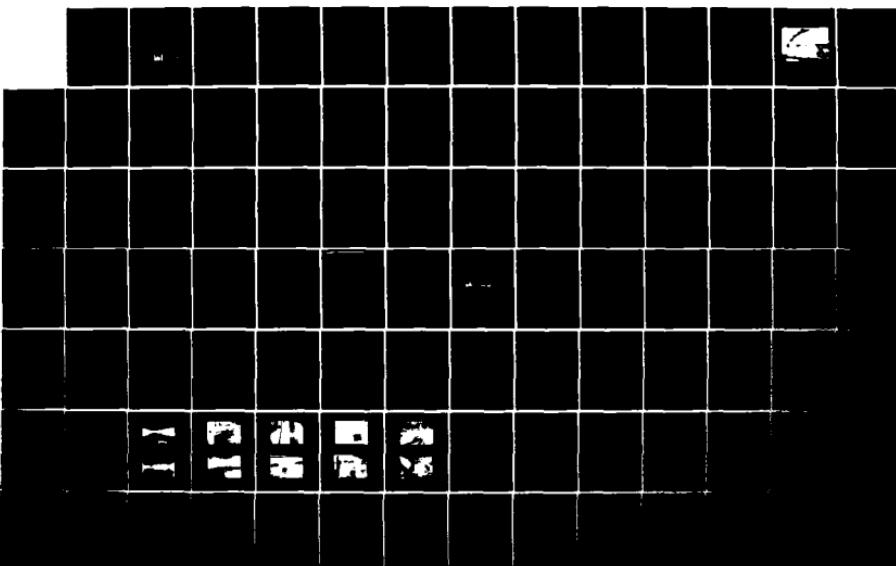
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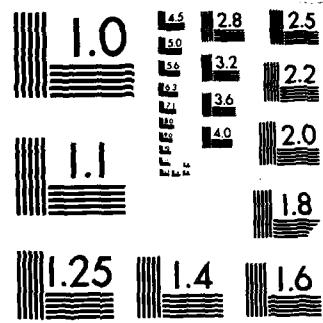
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COASTAL BASIN
EXETER, NEW HAMPSHIRE

EXETER WATER WORKS DAM
NH 00267

NHWRB NO. 82.02

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM



DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS. 02154

MARCH 1980

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| REPORT DOCUMENTATION PAGE | | READ INSTRUCTIONS BEFORE COMPLETING FORM |
|---|-----------------------|---|
| 1. REPORT NUMBER NH 00267 | 2. GOVT ACCESSION NO. | 3. RECIPIENT'S CATALOG NUMBER |
| 4. TITLE (and Subtitle) Exeter Water Works Dam | | 5. TYPE OF REPORT & PERIOD COVERED INSPECTION REPORT |
| 6. NATIONAL PROGRAM FOR INSPECTION OF NON-FEDERAL DAMS | | 7. PERFORMING ORG. REPORT NUMBER |
| 7. AUTHOR(s) U.S. ARMY CORPS OF ENGINEERS NEW ENGLAND DIVISION | | 8. CONTRACT OR GRANT NUMBER(s) |
| 9. PERFORMING ORGANIZATION NAME AND ADDRESS | | 10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS |
| 11. CONTROLLING OFFICE NAME AND ADDRESS DEPT. OF THE ARMY, CORPS OF ENGINEERS NEW ENGLAND DIVISION, NEEDED 424 TRAPELO ROAD, WALTHAM, MA. 02254 | | 12. REPORT DATE March 1980 |
| 13. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office) | | 13. NUMBER OF PAGES 64 |
| 14. SECURITY CLASS. (of this report) | | 15. SECURITY CLASS. (of this report) UNCLASSIFIED |
| 16. DISTRIBUTION STATEMENT (of this Report) APPROVAL FOR PUBLIC RELEASE: DISTRIBUTION UNLIMITED | | 16a. DECLASSIFICATION/DOWNGRADING SCHEDULE |
| 17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report) | | |
| 18. SUPPLEMENTARY NOTES Cover program reads: Phase I Inspection Report, National Dam Inspection Program; however, the official title of the program is: National Program for Inspection of Non-Federal Dams; use cover date for date of report. | | |
| 19. KEY WORDS (Continue on reverse side if necessary and identify by block number) DAMS, INSPECTION, DAM SAFETY, Coastal Basin Exeter, New Hampshire Dearborn Brook | | |
| 20. ABSTRACT (Continue on reverse side if necessary and identify by block number) The dam is an earthfill structure about 15 ft. high and 248 ft. long. The dam is considered to be in poor condition. There are various major concerns which must be corrected. The dam is small in size with a high hazard potential. It is recommended that the owner engage a qualified engineer to investigate the settlement of the crest of the dam and the soft, wet areas at the downstream toe of the dam and to do a detailed hydrological-hydraulic investigation. | | |

EXETER WATER WORKS DAM

NH 00267

NHWRB 82.02

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COASTAL BASIN
EXETER, NEW HAMPSHIRE



PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

**NATIONAL DAM INSPECTION PROGRAM
PHASE I - INSPECTION REPORT
BRIEF ASSESSMENT**

Identification No: NH 00267
Name of Dam: Exeter Water Works Dam
Town: Exeter
County and State: Rockingham, New Hampshire
Stream: Dearborn Brook
Date of Inspection: November 20, 1979

Exeter Water Works Dam is an earthfill structure approximately 15 feet high from bottom of reservoir to crest of dam and 248 feet long from the left abutment to the spillway structure. Located at the right abutment of the dam is the principal spillway which consists of a concrete spillway with stop logs and two sluice gates that discharge into a concrete and mortared stone sluiceway. There is no emergency spillway. The overall length of the dam, including the spillway structure, is 278 feet. The upstream face of the embankment is protected by a 1.0 foot thick concrete wall, and the earthfill structure is reinforced with steel sheetpiling which extends from the crest downward approximately 18 feet.

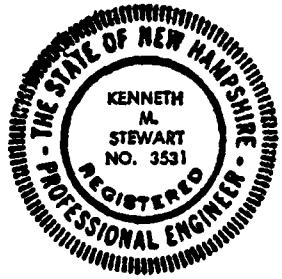
The dam impounds the Exeter Reservoir and the discharge flows to Wheelwright Brook and ultimately enters the Squamscott River approximately 0.75 miles below the dam. The dam was originally constructed to provide a primary water supply for the town of Exeter. However, its present use is as an auxiliary water supply since the Water Department currently pumps water to the water treatment facility from a nearby river. The reservoir is 0.53 miles in length with a surface area of about 18 acres. The maximum storage capacity is about 117 acre-feet.

As a result of the visual inspection and the review of available data regarding this facility, the dam is considered to be in POOR condition. Major concerns are: the presence of soft, wet ground and pools of standing water at the downstream toe of the dam and settlement of the crest of the dam in the order of 1 - 1-1/2 feet in the vicinity of the concrete intake structure which may be the result of seepage through the dam; lack of vegetation on the dirt road on the right abutment and on footpaths on the crest and downstream of the dam and partial loss of vegetation in the vehicle tracks at the toe of the dam which render these areas less resistant to erosion; the inadequacy of the spillway to pass the test flood; and animal burrows on the downstream slope of the dam.

This dam is classified as SMALL in size and a HIGH hazard structure in accordance with the recommended guidelines established by the Corps of Engineers. The test flood for this dam, therefore, ranges from one-half the Probable Maximum Flood (1/2 PMF) to the Probable Maximum Flood (PMF). Since the dam represents a high hazard structure, the full PMF was utilized for this hydrologic analysis. The test flood inflow was estimated to be 3,870 cfs, and resulted in an outflow discharge equal to 3,665 cfs which would overtop the dam crest by about 1.9 feet. The maximum spillway discharge capacity (stop logs removed and sluice gates open) with the water level at the dam crest was estimated to be 1,380 cfs or about 38 percent of the test flood discharge. A major breach with the reservoir surface at the dam crest would cause significant damage to the water treatment facility located directly below the dam, as well as the possible loss of life by more than a few individuals working therein. In addition, there would be significant damage done to Portsmouth Avenue (NH Route 108) which is a major commercial artery.

It is recommended that the owner engage a qualified registered engineer to investigate the settlement of the crest of the dam and the soft, wet areas at the downstream toe of the dam and to do a detailed hydrologic - hydraulic investigation to assess further the potential of overtopping the dam, the adequacy of the spillway to pass the test flood, and the need for and means to increase project discharge capacity. It is also recommended that the owner control trespassing on the embankment and abutments and maintain a cover of mowed grassy vegetation in those areas, remove the tree overhanging the downstream discharge channel, repair all spalled concrete, and insure the operability of all gates.

The recommendations and remedial measures are described in Section 7 and should be addressed by the owner within one year after receipt of this Phase I Inspection Report.



Kenneth M. Stewart
Kenneth M. Stewart
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N.H.P.E. 3531

S E A Consultants Inc.
Rochester, New Hampshire

PREFACE

This report is prepared under guidance contained in the Recommended Guidelines for Safety Inspection of Dams, for Phase I Investigations. Copies of these guidelines may be obtained from the Office of Chief of Engineers, Washington, D.C. 20314. The purpose of a Phase I investigation is to identify expeditiously those dams which may pose hazards to human life or property. The assessment of the general condition of the dam is based upon available data and visual inspections. Detailed investigation, and analyses involving topographic mapping, subsurface investigations, testing, and detailed computational evaluations are beyond the scope of a Phase I investigation; however, the investigation is intended to identify any need for such studies.

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with data available to the inspection team. In cases where the reservoir was lowered or drained prior to inspection, such action, while improving the stability and safety of the dam, removes the normal load on the structure and may obscure certain conditions which might otherwise be detectable if inspected under the normal operating environment of the structure.

It is important to note that the condition of a dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through continued care and inspection can there be any chance that unsafe conditions be detected.

Phase I inspections are not intended to provide detailed hydrologic and hydraulic analyses. In accordance with the established guidelines, the Spillway Test flood is based on the estimated "Probable Maximum Flood" for the region (greatest reasonably possible storm runoff), or fractions thereof. Because of the magnitude and

rarity of such a storm event, finding that a spillway will not pass the test flood should not be interpreted as necessarily posing a highly inadequate condition. The test flood provides a measure of relative spillway capacity and serves as an aide in determining the need for more detailed hydrologic and hydraulic studies, considering the size of the dam, its general condition and the downstream damage potential.

The Phase I investigation does not include an assessment of the need for fences, gates, no-trespassing signs, repairs to existing fences and railings and other items which may be needed to minimize trespassing and provide greater security for the facility and safety to the public. An evaluation of the project for compliance with OSHA rules and regulations is also excluded.

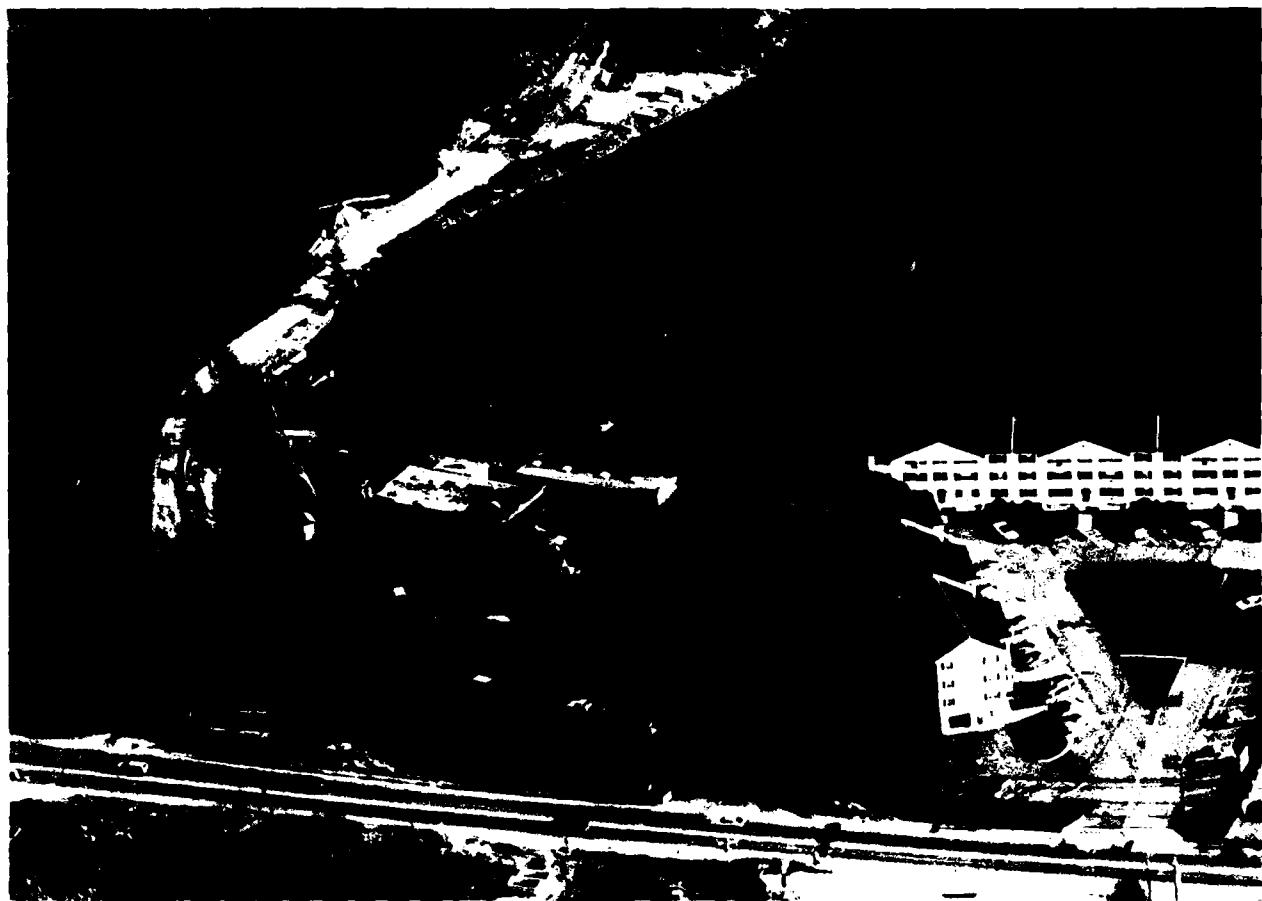
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OVERVIEW PHOTO - EXETER WATER WORKS DAM

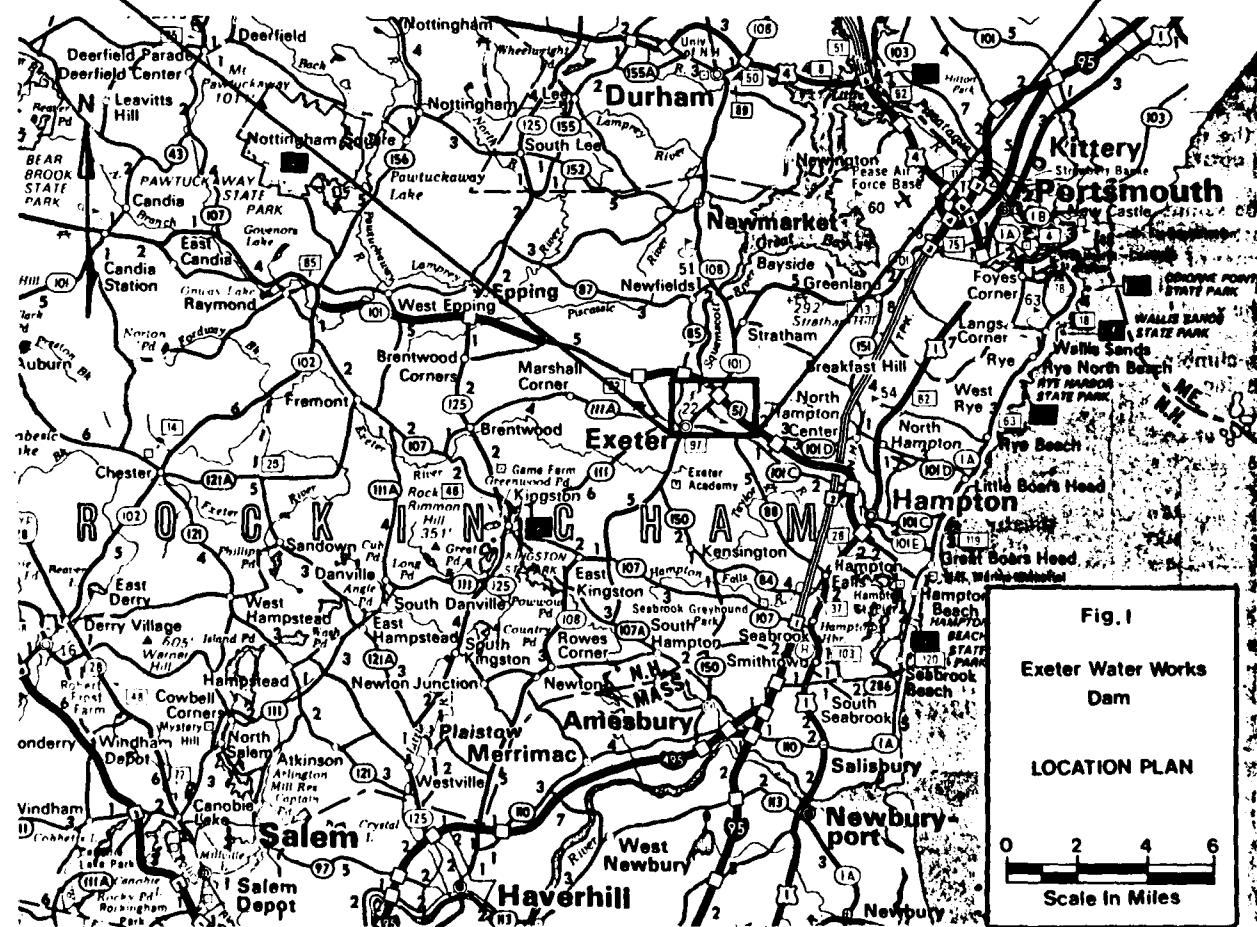
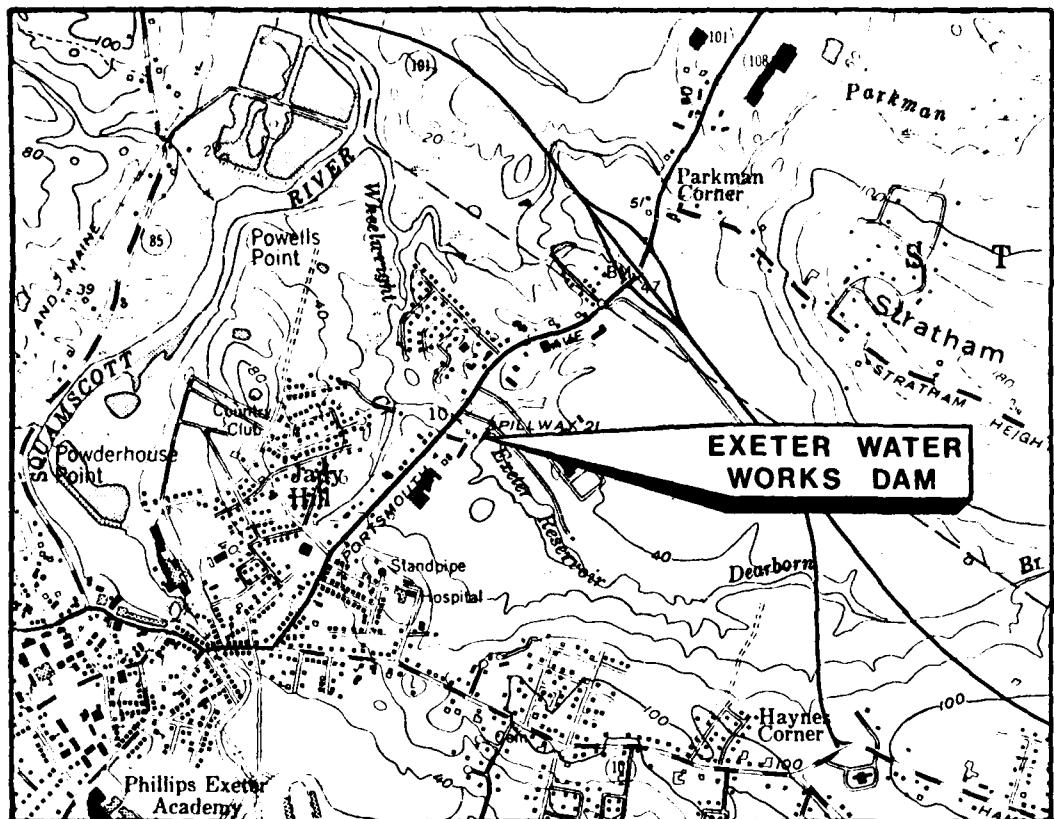


Fig. 1

Exeter Water Works Dam

LOCATION PLAN

Scale in Miles

NATIONAL DAM INSPECTION PROGRAM
PHASE I INSPECTION REPORT
EXETER WATER WORKS DAM

SECTION 1
PROJECT INFORMATION

1.1 General

a. Authority. Public Law 92-367, August 8, 1972, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a National Program of Dam Inspection throughout the United States. The New England Division of the Corps of Engineers has been assigned the responsibility of supervising the inspection of dams within the New England Region. S E A Consultants Inc. has been retained by the New England Division to inspect and report on selected dams in the State of New Hampshire. Authorization and notice to proceed were issued to S E A Consultants Inc. under a letter of November 5, 1979 from William Hodgson, Jr., Colonel, Corps of Engineers. Contract No. DACW33-80-C0008 has been assigned by the Corps of Engineers for this work.

b. Purpose

- (1) To perform technical inspection and evaluation of non-federal dams to identify conditions which threaten the public safety and thus permit correction in a timely manner by non-federal interests
- (2) To encourage and prepare the states to initiate quickly effective dam safety programs for non-federal dams
- (3) To update, verify and complete the National Inventory of Dams

1.2 Description of Project

a. Location. The Exeter Water Works Dam is located in the town of Exeter, New Hampshire, at the Exeter Water Treatment Plant, off Portsmouth Avenue (New Hampshire Route 108). The dam impounds water from Dearborn Brook, which after passing over the spillway, flows in a westerly direction through a concrete sluiceway into Wheelwright Brook in Exeter, New Hampshire. The dam is shown on USGS Quadrangle, Exeter, New Hampshire, with coordinates approximately at $N42^{\circ}59'14''$, $W70^{\circ}56'00''$, Rockingham County, New Hampshire. (See Location Plan.)

b. Description of Dam and Appurtenances. Exeter Water Works Dam is an earthfill structure approximately 15 feet high from bottom of reservoir to crest of dam, and 248 feet long from left abutment to the spillway structure. The upstream face consists of a 1.0 foot thick concrete wall which extends from the crest of the dam down approximately 7 feet to the top of a 2 foot thick stone riprap slope of approximately 1 foot vertical to 3 feet horizontal (1:3) which

terminates at the bottom of the reservoir. The earthfill structure is reinforced with steel sheetpiling which extends from the crest downward approximately 18 feet. The downstream slope of earthfill structure is approximately 1 foot vertical to 2 feet horizontal (1:2) to old ground. The crest width is approximately 7 feet.

Located at the right abutment of the dam is the principal spillway which consists of a concrete spillway with stop logs and two sluice gates that discharge into an 8 foot wide concrete and mortared stone sluiceway that extends approximately 220 feet to Wheelwright Brook.

Located approximately in the center of the earthfill structure is the principal intake structure which consists of two 16 inch diameter cast iron pipes beginning approximately 27 feet out from the face of the concrete wall at the reservoir bottom. The 16 inch diameter cast iron pipes discharge into a concrete intake chamber located at the center of the earth embankment. The chamber outlets into a 24 inch diameter cast iron pipe which discharges into the Exeter Water Treatment Plant building.

c. Size Classification. Small (height - 15 feet; storage - 117 acre-feet) based on storage (less than 1,000 acre-feet and greater than or equal to 50 acre-feet) as given in the Recommended Guidelines for Safety Inspection of Dams.

d. Hazard Classification. High Hazard. Failure of the dam would inundate the Exeter Water Treatment Plant which is located directly behind the dam. The water surface in the area of this facility would be more than 10 feet above the first floor. Consequently, this could result in the loss of life by more than a few individuals working at the water treatment facility. Also, the state highway located about 400 feet downstream of the dam would be impacted. Since the culverts beneath the road do not have the capacity to handle the dam failure discharge, the roadway would be overtopped by about 3 feet.

e. Ownership. The early structures of the dam are believed to have been constructed in 1886 when the initial Exeter Water Department Pump Station was built, and is owned by the Town of Exeter, Water Department, Portsmouth Avenue, Exeter, New Hampshire 03833. Telephone: (603) 778-0593.

f. Operator. The dam is maintained and operated by Nelson Belanger, Superintendent of the Exeter Water Department, Portsmouth Avenue, Exeter, New Hampshire 03833. Telephone: (603) 778-0593.

g. Purpose of Dam. The dam was originally constructed to provide a primary water supply for the town of Exeter. In 1977 the Water Department began pumping water to the water treatment facility from a nearby river, making the Exeter Reservoir an auxiliary water supply.

h. Design and Construction History. No information regarding the original design or construction of the dam was found. The early structures of the dam are believed to have been constructed in 1886 when the initial Exeter Water Department Pump Station was built. In April of 1973, the dam was intentionally breached by blasting the spillway. This apparently was done to protect the new construction of the water treatment facility and an apartment building near the dam, which

were being threatened by stormwater runoff that had filled the reservoir. Consequently, reconstruction of the dam and spillway as designed by Weston and Sampson Engineers, Boston, Massachusetts, was begun in 1973 by Harvey Construction Company of Manchester, New Hampshire. These design plans indicate the earthfill structure is constructed of a clay core built on an earth foundation. The plans and borings are available at the New Hampshire Water Resources Board. No in-depth design calculations or as-built drawings were disclosed for this dam.

i. Normal Operating Procedure. The Exeter Water Works Dam is used primarily for the retention of the Exeter Reservoir which acts as an auxiliary water supply for the town of Exeter. The normal operating procedure for this dam is to leave all the stop logs in unless the reservoir has to be lowered to facilitate repairs.

1.3 Pertinent Data

a. Drainage Area. The drainage area above the Exeter Water Works Dam covers nearly 1.8 square miles (1,150 acres), consisting of gently sloped hills surrounding relatively broad flat areas near Dearborn Brook and the reservoir. The majority of the drainage basin is heavily wooded and predominantly undeveloped. The major portion of the development lies on the southern fringe of the drainage area and consists of residential housing. An industrial firm is also located in the watershed, approximately 400 feet east (upstream) of the dam.

The topography in the drainage basin ranges from an elevation of 180 (NGVD) to an elevation of 10 feet near the base of the dam. Dearborn Brook represents the main and only well defined tributary to the reservoir. The brook originates from a swampy area on the eastern end of the watershed and flows westerly to the reservoir.

b. Discharge at Damsite.

(1) The outlet works consist of a cast in place concrete spillway with a total weir length of approximately 51 feet. The reservoir is normally maintained at an elevation of 22.95 feet NGVD, but it can be lowered by 2 feet, to elevation 20.95 feet, when the stop logs are removed. Two 2' x 2' sluice gates located at the base of the concrete spillway wall allow the reservoir to be lowered to an elevation of 15.95 feet. The water treatment facility's intake structure located in the center of the dam can draw water from the reservoir, but at present, the intake gates are closed.

(2) Maximum known flood at damsite - not known

(3) Ungated spillway capacity at top of dam

(a) Stop logs in place - 480 cfs at 24.65 elevation (375 cfs weir, 105 cfs sluice gates)

(b) Stop logs removed - 1,380 cfs at 24.65 elevation (1,275 cfs weir, 105 cfs sluice gates)

- (4) Ungated spillway capacity at test flood elevation
 - (a) Stop logs in place - 1,310 cfs at 26.55 elevation (1,190 cfs weir, 120 cfs sluice gates)
 - (b) Stop logs removed - 2,595 cfs at 26.55 elevation (2,475 cfs weir, 120 cfs sluice gates)
- (5) Gated spillway capacity at normal pool elevation - 500 cfs at 22.95 elevation upon removal of all stop logs
- (6) Gated spillway capacity at test flood elevation
 - (a) Stop logs in place - 1,190 cfs at 26.55 elevation
 - (b) stop logs removed - 2,475 cfs at 26.55 elevation
- (7) Total spillway capacity at test flood elevation
 - (a) Stop logs in place - 1,310 cfs at 26.55 elevation (1,190 cfs weir, 120 cfs sluice gates)
 - (b) Stop logs removed - 2,595 cfs at 26.55 elevation (2,475 cfs weir, 120 cfs sluice gates)
- (8) Total project discharge at top of dam
 - (a) Stop logs in place, gates closed 420 cfs at 24.65 elevation (375 cfs weir, 45 cfs bypass at right abutment)
 - (b) Stop logs removed, gates closed 1,320 cfs at 24.65 elevation (1,275 cfs weir, 45 cfs bypass at right abutment)
 - (c) Stop logs removed, gates open 1,425 cfs at 24.65 elevation (1,275 cfs weir, 105 cfs sluice gates, 45 cfs bypass at right abutment)
- (9) Total project discharge at test flood elevation - 3,665 cfs at 26.55 elevation

c. Elevation (feet, NGVD) based on datum information from plans of dam reconstruction by Weston and Sampson Engineers

- (1) Streambed at toe of dam - 10.93
- (2) Bottom of cutoff - unknown
- (3) Maximum tailwater - unknown
- (4) Normal pool - 22.95
- (5) Full flood control pool - N/A
- (6) Spillway crest (gated) - 22.95 feet (stop logs in place)
20.95 feet (stop logs removed - permanent crest)
- (7) Design surcharge (Original Design) - unknown
- (8) Top of dam - 24.65
- (9) Test flood design surcharge - 26.55

d. Reservoir (Length in feet)

- (1) Normal pool - 2,800
- (2) Flood control pool - N/A
- (3) Spillway crest pool - 2,000 (permanent crest)
2,800 (stop logs in place)
- (4) Top of dam - 3,500
- (5) Test flood pool - 4,300

e. Storage (acre-feet)

- (1) Normal pool - 79
- (2) Flood control pool - N/A
- (3) Spillway crest pool - 52 (permanent crest)
79 (stop logs in place)
- (4) Top of dam - 117
- (5) Test flood pool - 180

f. Reservoir Surface (acres)

- (1) Normal pool - 18 (stop logs in place)
- (2) Flood control pool - N/A
- (3) Spillway crest - 9.2 (permanent crest)
- (4) Test flood pool - 35.5
- (5) Top of dam - 26

g. Dam

- (1) Type - earthfill with upstream concrete wall and concrete spillway
- (2) Length - 248 feet (dam embankment)
278 feet (overall)
- (3) Height - 15 feet maximum
- (4) Top width - 7 feet
- (5) Side slopes - upstream 1V to 3H riprap to reservoir bottom,
downstream 1V to 2H earth to toe of slope
- (6) Zoning - unknown
- (7) Impervious core - clay
- (8) Cutoff - unknown
- (9) Grout curtain - none
- (10) Other - none

h. Diversion and Regulating Tunnel

Not applicable (See Section j below).

i. Spillway

- (1) Type - The spillway is a concrete U-shaped structure (see Plans and Details in Appendix B and Photo No. 14 in Appendix C) with a straight drop from the weir crest to the bottom of the sluiceway
- (2) Length of weir - 51.0 feet
- (3) Crest elevation - 22.95 (with stop logs), 20.95 (permanent crest)
- (4) Gates - two 2' x 2' sluice gates

(5) U/S Channel - Exeter Reservoir. The banks are tree lined. The slopes of the reservoir appear stable. No evidence of significant sedimentation was observed. There is one tree overhanging the approach channel to the spillway. The channel is wide and otherwise unobstructed.

(6) D/S Channel - The dam's spillway discharges into a concrete sluiceway having an average width of 8 feet and average depth of 3.5 feet. The sluiceway runs in a westerly direction for about 220 feet from the spillway to a point where it discharges into Wheelwright Brook. The brook continues in a westerly direction for about 180 feet where it passes underneath Portsmouth Avenue (NH Route 108) through one 6 foot diameter and one 4 foot diameter corrugated pipe. From here the brook follows a well defined channel about 10 feet in width with heavy overgrowth for approximately 300 feet where it discharges into an open swampy area.

j. Regulating Outlets

- (1) Invert - Spillway sluice gates - 15.95
- (2) Size - Spillway sluice gates - 2' x 2' opening
- (3) Description - Spillway sluice gates - two gates with 2' x 2' openings at bottom of spillway outlet
- (4) Control mechanism - Spillway sluice gates - manual crank-type operators on service bridge open and close gates

(5) Other

- (a) The water works intake from the reservoir consists of two 16-inch cast iron pipes controlled by gates in the intake structure. A 24-inch pipe carries the outflow from this structure to the water treatment facility and cannot be used to drain the reservoir. A 6-inch drain runs from the bottom of the intake structure and discharges into the sluiceway. This drain pipe could be used to dewater the reservoir, but its purpose seems to be to dewater only the intake structure.
- (b) The 1973 dam restoration plans indicate the existence of another 16-inch cast iron pipe approximately midway between the spillway and the intake structure at invert elevation 4.4 (NGVD). Exeter Water Department personnel say the pipe is controlled by a valve located at the toe of the downstream slope of the dam and the pipe discharges into the sluiceway. A 16-inch pipe which was full of small stones was observed in the concrete sluiceway bottom just below the footbridge. Although it was not possible to verify, this pipe appears to be able to dewater the reservoir to a point significantly below the invert of the sluice gates.

SECTION 2 ENGINEERING DATA

2.1 Design

A set of plans dated 1973 showing plan, elevation, and section for repairs to the dam and construction of a new spillway are available at the State of New Hampshire Water Resources Board. The boring logs for this reconstruction were also available. No in-depth engineering calculations, as-built drawings, or specifications were found.

2.2 Construction

No construction records are available for use in evaluating the dam. Records from the State of New Hampshire Water Resources Board indicate construction and repairs to the dam began in late 1973 by Harvey Construction of Manchester, New Hampshire.

2.3 Operation

No engineering operational data was found.

2.4 Evaluation

a. Availability. Repairs to the Exeter Water Works Reservoir Dam was designed by Weston and Sampson, Engineers, Boston, Massachusetts. Other than the plans and boring logs described above, no additional engineering data was found to be available.

b. Adequacy. Available engineering data and drawings are considered adequate for a Phase I investigation.

c. Validity. The field investigation indicated that the external features of the Exeter Water Works Dam substantially agree with those shown on the furnished plans. The only apparent difference is that the visual end of sheetpiling at the left abutment is 50 feet shorter than shown on the plans.

SECTION 3 VISUAL INSPECTION

3.1 Findings

a. General. Exeter Water Works Dam impounds a reservoir of small size. The watershed above the dam consists of gently sloped hills surrounding relatively broad flat areas near Dearborn Brook and the reservoir. The majority of the drainage basin is heavily wooded and predominantly undeveloped. The downstream area is heavily developed until it passes underneath Portsmouth Avenue (NH Route 108).

The field inspection of Exeter Water Works Dam was made on November 20, 1979. The inspection team consisted of personnel from S E A Consultants Inc. and Geotechnical Engineers Inc. Inspection checklists, completed during the visual inspection, are included in Appendix A. At the time of inspection, the center section of spillway stop logs had been removed and water was passing approximately 2 inches deep over the 8 foot wide spillway thus provided. The pool elevation was at approximately 21.14 NGVD. The upstream face of the dam could only be inspected above this water level.

b. Dam. Exeter Water Works Dam is an earthen embankment about 15 feet high, 248 feet long, and 7 feet wide at the crest.

The crest of the dam is mostly covered with unmowed grass and coarse weeds (see Photo No. 11). There is a footpath partially bare of vegetation along the crest (see Photos No. 4 through 6). The upstream side of the embankment is retained by a 1.0 foot thick vertical concrete wall. There is a 1/8-inch crack in this wall approximately 18 feet from the left end of the wall (see Photo No. 10). About 2-1/2 feet downstream of this concrete wall there is a sheetpile wall which extends from the concrete spillway structure at the right end of the dam to a point near the left abutment. The crest of the dam appears to have settled about 1 - 1-1/2 feet in the vicinity of the concrete control tower which is located approximately at the center of the dam (see Photo No. 9).

The downstream slope of the dam is inclined at 1 foot vertical to 2 feet horizontal and is covered with a thick growth of grass and coarse weeds (see Photo No. 11). There are two footpaths bare of vegetation on the downstream slope near the right end of the dam. There are several animal burrows on the downstream slope (see Photo No. 13). The downstream slope of the dam is wet and soft on the downslope side of the control tower.

The ground next to the downstream toe of the dam was generally wet and soft at the time of the inspection, and there was standing water at several spots along the toe (see Photo No. 11 and Plans and Details in Appendix B). Vehicles driven along the toe of the dam have caused some rutting and loss of vegetation (see Photo No. 12).

Both the right and left abutments appear to be earth. No bedrock outcrops were observed.

Several pine trees are growing on the left abutment at about the same elevation as the top of the dam (see Photo No. 5). A pipe is discharging water on the upstream slope of the dam near the left abutment, and a bed of boulders has been placed on the slope below the end of the pipe, apparently to reduce erosion. Trespassing has destroyed some of the vegetation growing on the downstream side of the left abutment.

There is a dirt road bare of vegetation on the right abutment adjacent to the concrete spillway structure (see Photos No. 6 and 7).

c. Appurtenant Structures. An intake chamber and control tower are located at the approximate center of the dam in the downstream crest. The intake chamber controls the intake of water into the water treatment plant. The structure was repaired in 1973 and at present appears to be generally in good condition and working order.

The principal spillway is located at the right end of the dam. It is a U-shaped concrete spillway approximately 26 feet wide with a total weir length of approximately 51 feet (see Photo No. 14). It was built in 1973 to replace the old structure which had been breeched. The permanent crest can accommodate removable stop logs to raise the ponding elevation approximately 2 feet. Two 2' x 2' sluice gates are located at the bottom of the spillway (see Photo No. 15). The sluice gates are operated by handwheel operators located directly above on the metal deck service bridge. The spillway, gates, service bridge and all other works related to this structure appear to be in good condition and working order except that rust buildup on the screw threads of the sluice gate operators indicates that the sluice gates have not been opened in some time.

There is a footpath, bare of vegetation, next to the right wall of the concrete and masonry sluiceway which extends a distance of about 220 feet from the concrete spillway structures to the natural earthen discharge channel downstream (see Photo No. 16). There are several small sinkholes in the earth fill behind the left wall of this same channel.

Erosion is occurring at the earthen headwall of a sedimentation basin that has been excavated on the right side of the concrete and masonry sluiceway mentioned in the preceding paragraph. This erosion is undermining a cyclone fence and trees and is progressing in the direction of the concrete spillway structure.

d. Reservoir Area. The slopes of the reservoir appear stable. No evidence of significant sedimentation was observed. There is one tree overhanging the approach channel to the spillway (see Photo No. 7). The channel is wide and otherwise unobstructed.

e. Downstream Channel. There is noticeable cracking and settlement of the concrete bottom of the sluiceway for approximately the first 100 feet down from the spillway.

There is one tree overhanging the channel between the end of the concrete and masonry channel that carries the sluiceway discharge and the highway culvert that is about 400 feet downstream of the dam (see Photo No. 17).

3.2 Evaluation

On the basis of the results of the visual inspection Exeter Water Works Dam is considered to be in poor condition.

The presence of a thick cover of grass and coarse weeds on the embankment and downstream toe makes it impossible to inspect those areas adequately, although several problems are observable as described below.

Settlement of the crest of the dam of the order of 1 - 1-1/2 feet in the vicinity of the concrete control tower and the presence of a wet, soft area on the downstream slope on the downslope side of the control tower indicate the presence of unknown conditions in the interior of the embankment which could lead to failure of the dam if not corrected.

The presence of soft, wet ground and pools of standing water at the downstream toe of the dam may be the result of seepage conditions which, if not controlled, could lead to failure of the dam. The rutting caused by vehicles at the toe of the dam and the partial loss of vegetation in the vehicle tracks will tend to exacerbate any unfavorable seepage conditions.

The lack of vegetation on the dirt road on the right abutment and on footpaths on the downstream slope, on the left abutment, and on the right side of the spillway discharge channel renders those areas less resistant to erosion by runoff from rainfall or due to overtopping if it should occur. Such erosion could result in failure of the dam.

Active erosion of the earthen headwall of the sedimentation basin on the right side of the sluiceway, which is progressing in the direction of the spillway, could lead to undermining of the spillway if not controlled.

The discharge of water from a pipe onto the upstream side of the left abutment has caused some erosion which has been temporarily alleviated by placing a pile of boulders in the discharge but which requires more permanent control measures.

Animal burrows on the downstream slope of the dam may be a focus for the development of seepage and piping.

Pine trees growing on the left abutment could cause seepage or erosion problems if a tree blows over and pulls out its roots or if a tree dies and its roots rot.

Sinkholes behind the wall on the left side of the concrete and masonry sluiceway discharge channel indicate a deterioration which, if allowed to continue, could result in erosion near the toe of the dam and exacerbation of seepage problems. Also cracking and settlement of the concrete bottom of the sluiceway indicates possible undermining of the sluiceway.

The tree overhanging the discharge channel upstream of the highway culvert could cause a blockage of the culvert pipes if it falls over and is carried downstream by water discharging from the reservoir.

SECTION 4 OPERATIONAL AND MAINTENANCE PROCEDURES

4.1 Operational Procedures

a. General. The Exeter Water Works Dam is used primarily for the retention of the Exeter Reservoir which acts as an auxiliary water supply for the town of Exeter. The normal operating procedure for this dam is to leave all the stop logs in unless the reservoir has to be lowered to facilitate repairs.

b. Description of Any Warning System in Effect

No written warning system exists for the dam.

4.2 Maintenance Procedures

a. General. The owner, Exeter Water Department, is responsible for the maintenance of the dam. No formal maintenance was discussed.

b. Operating Facilities

No formal plan for maintenance of operating facilities was disclosed.

4.3 Evaluation

The current operation and maintenance procedures for Exeter Water Works Dam are inadequate to ensure that all problems encountered can be remedied within a reasonable period of time. The owner should establish a written operation and maintenance procedure as well as establishing a warning system to follow in event of flood flow conditions or imminent dam failure.

SECTION 5 EVALUATION OF HYDROLOGIC/HYDRAULIC FEATURES

5.1 General. The Exeter Water Works Dam is an earthfill dam approximately 15 feet high and 248 feet long as measured from the spillway structure along the concrete face of the dam to the south end of the dam. The dam is located on the lower reaches of Dearborn Brook and impounds a reservoir which serves as a secondary water source for the town of Exeter and not as a flood control facility. The spillway structure, which has a total weir length of approximately 51 feet, constitutes the primary outlet for the reservoir. The two 2' x 2' sluice gates located at the base of the concrete spillway provide a means for lowering the reservoir surface 5 feet below the permanent weir crest. The Exeter Water Works Dam is classified as small in size having a maximum storage of approximately 117 acre-feet at the dam crest.

5.2 Design Data. No hydrologic or hydraulic design data were disclosed.

5.3 Experience Data. No experience data prior to or after the reconstruction of the dam and spillway were disclosed. Maximum flood flows or elevations are unknown.

5.4 Test Flood Analysis. Due to the absence of detailed design and operational information, the hydrologic evaluation was performed utilizing data gathered during field inspection, watershed size and an estimated test flood equal to the Probable Maximum Flood (PMF) as determined from the "rolling drainage area curve" in the Corps of Engineers set of guide curves.

Based on a drainage area of 1.8 square miles and a Maximum Probable Flood Peak Flow Rate of 2,150 cfs/sq mile, the test flood inflow was estimated to be 3,870 cfs. The test flood was routed through the dam in accordance with the Corps of Engineers procedure for Estimating Effect of Surcharge Storage on Maximum Probable Discharge. The discharge was estimated to be 3,665 cfs. This analysis indicated that the dam crest would be overtopped by 1.9 feet. The maximum spillway capacity (stop logs removed and sluice gates open) with the water level at the dam crest was estimated to be 1,380 cfs, which is only about 38 percent of the test flood discharge.

The spillway outlet channel has sufficient capacity (approximately 1,920 cfs) to handle the maximum outflow from the spillway structure with the reservoir level at the dam crest. However, below the reconstructed spillway structure, the sluiceway is narrower, not as deep, and has a reduced slope. Consequently, the maximum capacity of the sluiceway is only about 320 cfs. For flows greater than this value, the sluiceway channel will overflow, and the water surface will spread laterally as it approaches the culverts beneath Portsmouth Avenue.

5.5 Dam Failure Analysis. The impact of dam failure with the reservoir surface at the dam crest was assessed utilizing the "Rule of Thumb" Guidance for Estimating Downstream Dam Failure Hydrographs published by the Corps of Engineers. Based on this analysis, the dam has been classified as high hazard.

Portsmouth Avenue, which crosses the stream channel approximately 400 feet below the spillway, poses a significant barrier to flow through the stream channel. The culverts beneath the roadway do not have the capacity to handle the discharge resulting from a major break at the dam or the test flood. A major break would result in appreciable damage to the water treatment facility, as well as the possible loss of life by more than a few individuals working therein, since the water treatment facility is located directly behind the dam and since the stage of the stream in this reach of the channel would be nearly 22 feet (NGVD) or more than 10 feet above the first floor elevation of the water treatment facility.

A major break would also overtop Portsmouth Avenue by approximately 3 feet and would certainly close this major commercial artery temporarily as well as probably doing permanent damage by undermining the road surface. However, Portsmouth Avenue also functions as a secondary dike and significantly reduces further downstream hazards by regulating the rate of flow. This function is demonstrated by the significantly lower stages in the stream channel reaches below Portsmouth Avenue. Reach 2 immediately below Portsmouth Avenue has a maximum stage of nearly 16 feet (NGVD) and the discharge in this reach should be confined to the stream channel. Reach 3 has a maximum stage of approximately 9 feet (NGVD) and should be well below the sills of any structures located near the stream channel.

SECTION 6

EVALUATION OF STRUCTURAL STABILITY

6.1 Visual Observations. The visual examination indicates the following potential structural problems.

- a. Settlement of the crest of the dam in the order of 1 - 1-1/2 feet in the vicinity of the concrete control tower and the presence of a wet, soft area on the downstream slope on the downslope side of the control tower indicate the presence of unknown conditions in the interior of the embankment which could lead to failure of the dam if not corrected.
- b. The presence of soft, wet ground and pools of standing water at the downstream toe of the dam may be the result of seepage conditions which, if not controlled, could lead to failure of the dam. The rutting caused by vehicles at the toe of the dam and the partial loss of vegetation in the vehicle tracks will tend to exacerbate any unfavorable seepage conditions.
- c. The lack of vegetation on the dirt road on the right abutment and on footpaths on the downstream slope, on the left abutment and on the right side of the spillway discharge channel renders those areas less resistant to erosion by runoff from rainfall or due to overtopping if it should occur. Such erosion could result in failure of the dam.
- d. Active erosion of the earthen headwall of the sedimentation basin on the right side of the spillway discharge channel, which is progressing in the direction of the spillway, could lead to undermining of the spillway if not controlled.
- e. The discharge of water from a pipe onto the upstream side of the left abutment has caused some erosion which has been temporarily alleviated by placing a pile of boulders in the discharge but which requires more permanent control measures.
- f. Animal burrows on the downstream slope of the dam may be a focus for the development of seepage and piping.
- g. Pine trees growing on the left abutment could cause seepage or erosion problems if a tree blows over and pulls out its roots or if a tree dies and its roots rot.

A thick cover of grass and coarse weeds makes it impossible to inspect the embankment and downstream toe area adequately.

6.2 Design and Construction Data. No information regarding the original design or construction of the dam was found. The early structures of the dam are believed to have been constructed in 1886 when the initial Exeter Water Department Pump Station was built.

6.3 Post-Construction Changes. In 1973 repairs were made to the existing dam. These repairs were necessary because the dam was intentionally breached in April 1973 by blasting the existing spillway. This drastic action was apparently taken to protect the new construction of the water treatment facility and an apartment building near the dam, which were being threatened by stormwater runoff that had filled the reservoir. A new concrete spillway was constructed to replace the old structure. Sheetpiling was driven beneath the base of the spillway and behind the concrete face of the dam for most of its length. The intake chamber in the center of the dam was reconstructed and a chain hoist installed.

6.4 Seismic Stability. This dam is located in Seismic Zone 2 and, in accordance with the Phase I guidelines, does not warrant seismic analysis.

SECTION 7

ASSESSMENT, RECOMMENDATIONS, AND REMEDIAL MEASURES

7.1 Dam Assessment

a. Condition. The visual examination indicates that Exeter Water Works Dam is in poor condition. The major concerns with respect to the integrity of the dam are:

- (1) Settlement of the crest of the dam in the order of 1 -1-1/2 feet in the vicinity of the concrete control tower
- (2) Soft, wet area on the downstream slope of the dam downslope from the concrete control tower
- (3) Cracking and settlement of the concrete sluiceway bottom
- (4) Footpaths, bare of vegetation, on the downstream slope, on the left abutment, and on the right side of the spillway discharge channel
- (5) Dirt road, bare of vegetation, on the right abutment
- (6) Erosion of the earthen headwall of the sedimentation basin on the right of the sluiceway channel
- (7) Discharge of water from a pipe onto the upstream side of the left abutment
- (8) Animal burrows on the downstream slope of the dam
- (9) Trees growing on the left abutment
- (10) Sinkholes behind the wall on the left side of the concrete and masonry spillway discharge channel
- (11) Tree overhanging the downstream channel between the spillway and a highway culvert downstream of the dam
- (12) Inadequacy of the spillway to pass the test flood.

b. Adequacy of Information. (See comment under 6.2)

The information available from the visual inspection and hydraulic computations is adequate to identify the problems listed in 7.2. These problems will require the attention of a qualified registered professional engineer who will have to make additional engineering studies to design or specify remedial measures. No additional information is needed for the purposes of this Phase I investigation.

c. Urgency. The owner should implement the recommendations in 7.2 and 7.3 within one year after receipt of this Phase I report.

7.2 Recommendations

The owner should retain a registered professional engineer qualified in the design and construction of dams to:

- (1) Investigate the settlement of the crest of the dam in the vicinity of the concrete control tower and design remedial measures, if needed
- (2) Investigate the soft, wet areas on the downstream slope downslope of the concrete control tower and at the toe of the dam and design remedial measures, if needed
- (3) Investigate the cracking and settlement of the concrete sluiceway bottom and design remedial measures, if needed
- (4) Design or specify permanent procedures or construction for controlling erosion of the headwall of the sedimentation basin on the right side of the spillway discharge channel
- (5) Design or specify permanent procedures or construction for preventing erosion of the left abutment by water discharging from a pipe onto the upstream side of the abutment
- (6) Specify procedures for filling animal burrows on the downstream slope
- (7) Specify procedures for removal of trees and their root systems from the left abutment
- (8) Design remedial measures to repair the sinkholes behind the left wall of the spillway discharge channel
- (9) Do a detailed hydrologic-hydraulic investigation to assess further the potential for overtopping the dam, the adequacy of the spillway to pass the test flood, and the need for and means to increase project discharge capacity.

The owner should carry out the recommendations made by the engineer.

7.3 Remedial Measures

a. Operating and Maintenance Procedures. The owner should:

- (1) Monitor the soft, wet areas on the downstream toe and downstream slope periodically until the recommendations made in 7.2(1) and 7.2(2) have been carried out.
- (2) Keep the embankment and downstream toe area mowed.

- (3) Remove the tree overhanging the downstream discharge channel.
- (4) Control trespassing on the embankment and abutments and maintain a cover of grassy vegetation in those areas.
- (5) Repair all spalled concrete
- (6) Insure the operability of all gates
- (7) Verify the existence and operability of the reservoir drain line described in 1.3.j(5)(b).
- (8) Visually inspect the dam and appurtenant structures once a month.
- (9) Engage a registered professional engineer qualified in the design and construction of dams to make a comprehensive technical inspection of the dam once every year.
- (10) Establish a surveillance program for use during and immediately after heavy rainfall and also a warning program to follow in case of emergency conditions.

7.4 Alternatives

There are no practical alternatives to the recommendations of Section 7.2 and 7.3 except that on an interim basis, the owner may consider operating the reservoir at a lower level throughout the year so as to provide more storage for extreme flood events.

APPENDIX A
INSPECTION CHECK LIST

INSPECTION CHECK LIST
PARTY ORGANIZATION

PROJECT: Exeter Water Works Dam, NH

DATE: November 20, 1979

TIME: 0800

WEATHER: Cloudy, Cool

W.S. ELEV. 21.12 U.S. 5.00 DNS.
(U.S.G.S. Datum)

PARTY:

1. Kenneth Stewart, S E A
2. Robert Durfee, S E A
3. Bruce Pierstorff, S E A
4. Philip Ricardi, S E A
5. Ronald Hirschfeld, G E I

6. _____
7. _____
8. _____
9. _____
10. _____

| | PROJECT FEATURE | INSPECTED BY | REMARKS |
|-----|-----------------------------|---------------------------------|---------|
| 1. | <u>Structural Stability</u> | <u>K. Stewart/R. Durfee</u> | |
| 2. | <u>Hydrology/Hydraulics</u> | <u>B. Pierstorff/P. Ricardi</u> | |
| 3. | <u>Soils and Geology</u> | <u>R. Hirschfeld</u> | |
| 4. | _____ | | |
| 5. | _____ | | |
| 6. | _____ | | |
| 7. | _____ | | |
| 8. | _____ | | |
| 9. | _____ | | |
| 10. | _____ | | |

INSPECTION CHECK LIST

PROJECT: Exeter Water Works Dam, NH DATE: November 20, 1979
 PROJECT FEATURE: Dam Embankment NAME: _____
 DISCIPLINE: _____ NAME: _____

| AREA EVALUATED | CONDITIONS |
|---|--|
| DAM EMBANKMENT | |
| Crest Elevation | 24.65 |
| Current Pool Elevation | 21.12 |
| Maximum Impoundment to Date | Unknown |
| Surface Cracks | None observed |
| Pavement Condition | Not paved |
| Movement or Settlement of Crest | Settlement of 1-1/2 ft next to water works inlet structure |
| Lateral Movement | None observed |
| Vertical Alignment | See "Movement or Settlement of Crest" above |
| Horizontal Alignment | Good |
| Condition at Abutment and at Concrete Structures | Unpaved and ungrassed road at right abutment next to spillway. Wet soft area on embankment next to downstream edge of control tower. |
| Indications of Movement of Structural Items on Slopes | None observed |
| Trespassing on Slopes | Two footpaths on downstream slope near spillway |
| Vegetation on Slopes | Heavy cover of grass and weeds on downstream slope and in vicinity of toe makes it impossible to inspect those areas adequately. |
| Sloughing or Erosion of Slopes or Abutments | Sloughing and erosion of earthen headwall of sedimentation basin immediately downstream of right abutment. |
| Rock Slope Protection - Riprap Failures | No riprap |
| Unusual Movement or Cracking at or near Toe | None observed |
| Unusual Embankment or Downstream Seepage | Toe of dam is wet and soft, with some standing water over most of its lengths |
| Piping or Boils | None observed |
| Foundation Drainage Features | None observed |
| Toe Drains | None observed |
| Instrumentation System | None observed |

INSPECTION CHECK LIST

PROJECT: Exeter Water Works Dam, NH DATE: November 20, 1979

PROJECT FEATURE: Dike Embankment NAME: _____

DISCIPLINE: _____ NAME: _____

| AREA EVALUATED | CONDITIONS |
|---|-------------------|
| <u>DIKE EMBANKMENT</u> Crest Elevation Current Pool Elevation Maximum Impoundment to Date Surface Cracks Pavement Condition Movement or Settlement of Crest Lateral Movement Vertical Alignment Horizontal Alignment Condition at Abutment and at Concrete Structures Indications of Movement of Structural Items on Slopes Trespassing on Slopes Vegetation on Slopes Sloughing or Erosion of Slopes or Abutments Rock Slope Protection - Riprap Failures Unusual Movement or Cracking at or near Toes Unusual Embankment or Downstream Seepage Piping or Boils Foundation Drainage Features Toe Drains Instrumentation System | No dike |

INSPECTION CHECK LISTPROJECT: Exeter Water Works Dam, NHDATE: November 20, 1979PROJECT FEATURE: Intake Channel

NAME: _____

DISCIPLINE: _____

NAME: _____

| AREA EVALUATED | CONDITIONS |
|---|---------------------------------------|
| <u>OUTLET WORKS - INTAKE CHANNEL AND INTAKE STRUCTURE</u> | |
| a. Approach Channel | |
| Slope Conditions | Good |
| Bottom Conditions | Not visible beneath reservoir surface |
| Rock Slides or Falls | None |
| Log Boom | None |
| Debris | None |
| Condition of Concrete Lining | Not applicable |
| Drains or Weep Holes | None |
| b. Intake Structure | |
| Condition of Concrete | |
| Stop Logs and Slots | |

INSPECTION CHECK LIST

PROJECT: Exeter Water Works Dam, NH DATE: November 20, 1979

PROJECT FEATURE: Control Tower NAME: _____

DISCIPLINE: _____ NAME: _____

| AREA EVALUATED | CONDITIONS |
|--|--|
| OUTLET WORKS - CONTROL TOWER | |
| a. Concrete and Structural | |
| General Condition | Good |
| Condition of Joints | Good |
| Spalling | Moderate number of medium sized popouts |
| Visible Reinforcing | None |
| Rusting or Staining of Concrete | Slight rust staining on concrete at equipment hoist frame |
| Any Seepage or Efflorescence | None visible |
| Joint Alignment | Good |
| Unusual Seepage or Leaks in Gate Chamber | None visible |
| Cracks | None visible |
| Rusting or Corrosion of Steel | Slight to moderate rusting on inside chamber walls |
| b. Mechanical and Electrical | |
| Air Vents | Not applicable |
| Float Wells | Not applicable |
| Crane Hoist | Chain hoist for raising and lowering screens in good shape |
| Elevator | Not applicable |
| Hydraulic System | Not applicable |
| Service Gates | Not visible |
| Emergency Gates | Not visible |
| Lightning Protection System | Not applicable |
| Emergency Power System | None |
| Wiring and Lighting System | Good |

INSPECTION CHECK LIST

PROJECT: Exeter Water Works Dam, NH DATE: November 20, 1979

PROJECT FEATURE: Transition and conduit NAME: _____

DISCIPLINE: _____ NAME: _____

| AREA EVALUATED | CONDITIONS |
|---|-------------|
| <u>OUTLET WORKS - TRANSITION AND CONDUIT</u> General Condition of Concrete Rust or Staining on Concrete Spalling Erosion or Cavitation Cracking Alignment of Monoliths Alignment of Joints Numbering of Monoliths | Not visible |

INSPECTION CHECK LIST

PROJECT: Exeter Water Works Dam, NHDATE: November 20, 1979PROJECT FEATURE: Outlet Structure

NAME: _____

DISCIPLINE: _____

NAME: _____

| AREA EVALUATED | CONDITIONS |
|---|---|
| <u>OUTLET WORKS - OUTLET STRUCTURE AND OUTLET CHANNEL</u> | Not visible - outlet channel is 24" diameter cast iron pipe to water works. |
| General Condition of Concrete | Not applicable |
| Rust or Staining | Not applicable |
| Spalling | Not applicable |
| Erosion or Cavitation | Not visible |
| Visible Reinforcing | Not applicable |
| Any Seepage or Efflorescence | Not visible |
| Condition at Joints | Not visible |
| Drain holes | Not applicable |
| Channel | No channel - outlet is the inlet pipe for the water works. |
| Loose Rock or Trees Overhanging Channel | None |
| Condition of Discharge Channel | Not applicable |

INSPECTION CHECK LIST

PROJECT: Exeter Water Works Dam, NH DATE: November 20, 1979
 PROJECT FEATURE: Spillway Weir NAME: _____
 DISCIPLINE: _____ NAME: _____

| AREA EVALUATED | CONDITIONS |
|--|--|
| <u>OUTLET WORKS - SPILLWAY WEIR, APPROACH AND DISCHARGE CHANNELS</u> | |
| a. Approach Channel | |
| General Conditions | Good |
| Loose Rock Overhanging Channel | None |
| Trees Overhanging Channel | One tree overhanging channel immediately upstream of spillway |
| Floor of Approach Channel | Not visible beneath water surface |
| b. Weir and Training Walls | |
| General Condition of Concrete | Good |
| Rust or Staining | Slight staining at service bridge bearings |
| Spalling | None |
| Any Visible Reinforcing | None |
| Any Seepage or Efflorescence | None |
| Drain Holes | None observed |
| c. Discharge Channel | |
| General Condition | Fair. Several small sinkholes behind training wall on left side of masonry sluiceway wall. |
| Loose Rock Overhanging Channel | None |
| Trees Overhanging Channel | One tree overhanging channel between downstream end of discharge sluiceway and highway culvert |
| Floor of Channel | Concrete-lined channel |
| Other Obstructions | None |

INSPECTION CHECK LIST

PROJECT: Exeter Water Works Dam, NH

DATE: November 20, 1979

PROJECT FEATURE: Service Bridge

NAME: _____

DISCIPLINE: _____

NAME: _____

| AREA EVALUATED | CONDITIONS |
|--------------------------------------|--|
| <u>OUTLET WORKS - SERVICE BRIDGE</u> | |
| a. Super Structure | |
| Bearings | Good |
| Anchor Bolts | Slight rusting, no washers provided |
| Bridge Seat | Good |
| Longitudinal Members | Good |
| Under Side of Deck | Slight Rusting |
| Secondary Bracing | Good |
| Deck | Slight Rusting |
| Drainage System | Not applicable |
| Railings | Good |
| Expansion Joints | None |
| Paint | Fair. Slight rusting throughout structure. |
| b. Abutment & Piers | |
| General Condition of Concrete | Good. Slight rust stains at bearings. |
| Alignment of Abutment | Good |
| Approach to Bridge | Not applicable |
| Condition of Seat & Backwall | Good |

APPENDIX B
ENGINEERING DATA

AVAILABLE ENGINEERING DATA

A set of plans dated 1973 showing plan, elevation and sections for repairs are available at the New Hampshire Water Resources Board, 37 Pleasant Street, Concord, New Hampshire 03301. The boring logs for these repairs are also available.

PAST INSPECTION REPORTS



State of New Hampshire

WATER RESOURCES BOARD

37 Pleasant Street
Concord, N.H. 03301

TELEPHONE 271-3405

July 12, 1978

Town of Exeter
Water Department
Exeter, New Hampshire 03833

Dear Sir:

Under the provisions of RSA Chapter 482, Sections 8 through 15, the New Hampshire Water Resources Board is authorized to inspect all dams in the state which by reason of their physical condition, height, and location may be a menace to the public safety.

The dam structure (Dam # 82.02) located on your property in Exeter, New Hampshire was inspected on April 15, 1977 and as a result of this inspection no visual discrepancies were found at the time of the inspection which would require any corrective measures.

This letter is provided for your information only. If you have any questions, please feel free to call or write.

Sincerely yours,

A handwritten signature in black ink, appearing to read "George W. McGee, Jr." above "George W. McGee, Sr."
George W. McGee, Sr.
Chairman

GMG/kn

NEW HAMPSHIRE WATER RESOURCES BOARD

INSPECTION REPORTTown: Exeter Dam Number: 82.02Name of Dam, Stream and/or Water Body: Exeter Res.Owner: Exeter Water Works Telephone Number: _____

Mailing Address: _____

Max. Height of Dam: 17' Pond Area: 22 ± A Length of Dam: 300'FOUNDATION: Earth Type unknownOUTLET WORKS: 50' overflow spillway with 12" FlashboardsFlash boards will not fail!!16" CI Pipe pond drain2- 2'x2' waste gatesABUTMENTS: Concrete in good shapeEMBANKMENT: Earth with concrete on upstream face2' I vegetated downstream20' long steel sheet piling through & of embankment

SPILLWAY: Length: 50 Freeboard: 4' (3' with flashboards)

SEEPAGE: Location, estimated quantity, etc.

None

Changes Since Construction or Last Inspection:

Tail Water Conditions:

Overall Condition of Dam: Good

Contact With Owner: Yes M. Betanger (water works Supt.)

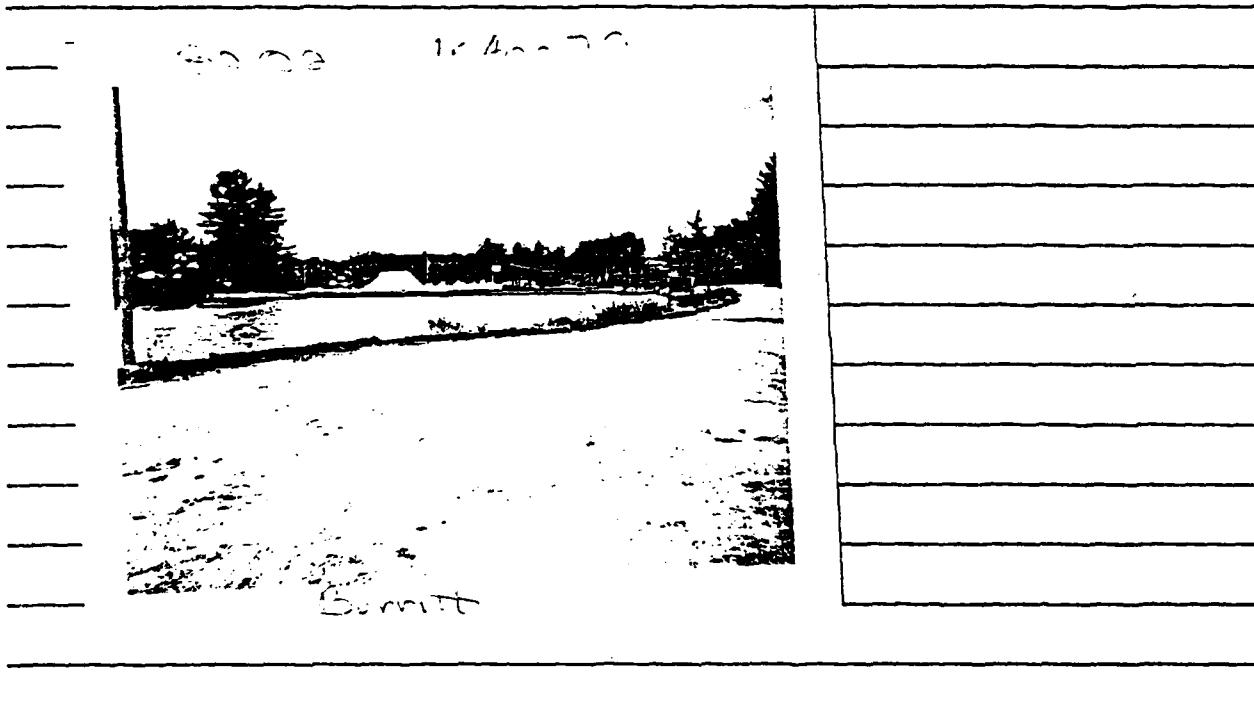
Date of Inspection: 15 Apr 77 Suggested Reinspection Date _____

Class of Dam: Manage A

Signature J. B. Bunt

Date 15 Apr 77

COMMENTS:



NEW HAMPSHIRE
WATER RESOURCES BOARD

SITE EVALUATION DATA

OWNER: Exeter Water Works TELEPHONE NO. _____

MAILING ADDRESS: _____

SITE LOCATION (TOWN OR CITY) Exeter

NAME OF STREAM OR WATERBODY: Exeter Res

QUADRANGLE: Exeter - 7.5 mi LOCATION

HEIGHT OF (PROPOSED, EXISTING) DAM 17 LENGTH 300

TYPE OF (PROPOSED, EXISTING) STRUCTURE Earth Embankment

DRAINAGE AREA 1,6 ± 5m POND AREA 32 A±

AVAILABLE ARTIFICIAL STORAGE: PERMANENT: _____ TEMPORARY: _____ TOTAL 200 Af

EXISTING DEVELOPMENT DOWNSTREAM OF (PROPOSED, EXISTING) STRUCTURE _____

Highway water treatment plant

POTENTIAL DEVELOPMENT DOWNSTREAM OF (PROPOSED, EXISTING) STRUCTURE _____

POTENTIAL DAMAGE DOWNSTREAM OF STRUCTURE (EXPLAIN IN DETAIL AND INCLUDE ANY POTEN-

TIAL LOSS OF LIFE: ESTIMATE) washout of Treatment Plant

wash out of Road

OTHER COMMENTS: _____

CLASS OF STRUCTURE -- NON MENACE: MENACE A B C DAM # 82-02

DATE OF INSPECTION: 15 Apr 77

SIGNED

SIGNATURE

DATE:

N. H. WATER RESOURCES BOARD
Concord, N. H. 03301

DAM SAFETY INSPECTION REPORT FORM

Town: Exeter

Dam Number: 82.02

Inspected by: R.B. Chamberlain /DRR/psm Date: 4/25 & 4/5 1973

Local name of dam or water body: Exeter Reservoir

Owner: Town of Exeter Address: _____

Owner was not interviewed during inspection.

Drainage Area: 1.6 T sq. mi. Stream: Dearborn Brook

Pond Area: 22 T Acre, Storage 200 Ac-Ft. Max. Head 7 Ft.

Foundation: Type Earth, Seepage present at toe - Yes/No, _____

Spillway: Type concrete, Freeboard over perm. crest: 4',

Width 17.5', Flashboard height 1',

Max. Capacity 440 cfs c.f.s.

Embankment: Type earth, Cover Soil Width _____,

Upstream slope 3 to 1; Downstream slope 2 to 1

Abutments: Type concrete, Condition: Good, Fair, Poor

Gates or Pond Drain: Size 16' pipe Capacity _____ Type PIPE

Lifting apparatus _____ Operational condition _____

Changes since construction or last inspection: Dike failed under care mill
adjacent to pipe manhole, spillway was lowered 4 feet
downstream construction.

Downstream development: LARGE WATER TREATMENT plant 13-mi downstream

This dam would not be a menace if it failed.

Suggested reinspection date: During fall or repairs

Remarks: WATER TREATMENT PLANT BEING BUILT BELOW DAM. Pond
has been empty since 1972. Pond will be used as part of plant.

M E M O R A N D U M

DATE: April 12, 1973
FROM: Robert B. Chamberlin, Civil Engineer
SUBJECT: Exeter Water Works Dam - No. 82.02
TO: Vernon A. Knowlton, Chief Engineer, Water Resources Board

On April 4, 1973, I inspected the dam at the Water Works of Exeter. The reservoir had been drained last year with our permission to inspect the intake pipe and valves for possible use in the new water treatment plant they are installing this year. According to the newspaper account attached, the reservoir filled during the storm of April 2, 1973, and possible damage to the new construction and an apartment house was the reason to remove the spillway by blasting on April 3, 1973.

At the time of inspection, emergency repairs were being conducted at three different points. The remains of the concrete spillway which was blasted were being removed by an air hammer. The hole in the center of the dam where the intake pipe goes through the dam to a large manhole containing valves was being filled with sand bags. The erosion of the bank toward the apartment house on the left side of the dam was being filled rapidly with a sandy material pushed in by a bulldozer.

This dam was classified as a menace dam during 1935 and 1949 inspections.

RBC:js

NEW HAMPSHIRE WATER CONTROL COMMISSION

REPORT ON DAM INSPECTION

TOWN Exeter DAM NO. 82,02 STREAM Dearborn BrookOWNER Water Dept., Town of Exeter ADDRESS Exeter, N.H.In accordance with Section 20 of Chapter 133, Laws of 1937, the above dam was inspected by me on 9/26/49 accompanied by carolaker

NOTES ON PHYSICAL CONDITION

Abutments GoodSpillway Fair - cracks have been plastered up to prevent loss of full pond.Gates Earth Embankment Fair - no signs of leakage

CHANGES SINCE LAST INSPECTION

Spillway is straightened, channel.Concrete cutoff wall looks sound.FUTURE INSPECTIONS YesThis dam (is) (is not) a menace because State Hwy immediately downstream.REMARKS SatisfactoryWater Supply

| Copy to Owner | Date |
|---------------|------|
| | |
| | |
| | |
| | |

P. C. M. 1949
INSPECTOR

NEW HAMPSHIRE WATER CONTROL COMMISSION
DATA ON DAMS IN NEW HAMPSHIRE

| | | | |
|-----------------------|-----------------------|-----------------|-------------------|
| LOCATION | STATE NO. | 82.03..... | |
| Town | Exeter..... | County | Rockingham..... |
| Stream | Exeter Reservoir..... | | |
| Basin-Primary | Ocean..... | Secondary | Exeter River..... |
| Local Name | | | |
| Coordinates—Lat. | 43° 00' -4,800 | Long. | 70° 55' +4,800 |

GENERAL DATA

Drainage area: Controlled Sq. Mi.: Uncontrolled Sq. Mi.: Total 1.62 Sq. Mi.
Overall length of dam 300 ft.: Date of Construction
Height: Stream bed to highest elev. 17' ft.: Max. Structure 13' 5" ft.
Cost—Dam: Reservoir

DESCRIPTION E—Concrete Stone—Gravity Type ✓

Waste Gates

Type

Number: Size ft. high x ft. wide

Elevation Invert: Total Area sq. ft.

Hoist

Waste Gates Conduit

Number: Materials

Size ft.: Length ft.: Area sq. ft.

Embankment

Type

Height—Max. ft.: Min. ft.

Top—Width: Elev. ft.

Slopes—Upstream on: Downstream on

Length—Right of Spillway: Left of Spillway

Spillway

Materials of Construction

Length—Total ft.; Net 17' -5" / ft.

Height of permanent section—max. 13' 5" ft.: Min. ft.

Flashboards—Type: Height 10" ft.

Elevation—Permanent Crest: Top of Flashboard

Flood Capacity 430 cfs.: cfs/sq. mi.

Abutments

Materials:

Freeboard: Max. 4' 0" ✓ ft.: Min. ft.

Headworks to Power Devel.—(See "Data on Power Development")

OWNER Exeter Water Works

REMARKS Use—Conservation

NEW HAMPSHIRE WATER RESOURCES BOARD

INVENTORY OF DAMS AND WATER POWER DEVELOPMENTS

DAM

BASIN Ocean NO. 2 — III — I-4774
 RIVER Exeter Reservoir MILES FROM MOUTH 0 D.A.SQ.MI.
 TOWN Exeter OWNER Exeter Water Board, Exeter
 LOCAL NAME OF DAM
 BUILT _____ DESCRIPTION Gravity — Earth, Concrete, stone
on Earth

POND AREA-ACRES 1 DRAWDOWN FT. 17 POND CAPACITY-ACRE FT. 1
 HEIGHT-TOP TO BED OF STREAM-FT. 17 MAX. MIN.
 OVERALL LENGTH OF DAM-FT. 300 MAX. FLOOD HEIGHT ABOVE CREST-FT.
 PERMANENT CREST ELEV.U.S.G.S. _____ LOCAL GAGE
 TAILWATER ELEV.U.S.G.S. _____ LOCAL GAGE
 SPILLWAY LENGTHS-FT. 17.47 FREEBOARD-FT. 2.
 FLASHBOARDS-TYPE, HEIGHT ABOVE CREST 0.633
 WASTE GATES-NO. WIDTH MAX. OPENING DEPTH SILL BELOW CREST

REMARKS Condition fair
Enters Wigginton Brook, Exeter R.

POWER DEVELOPMENT

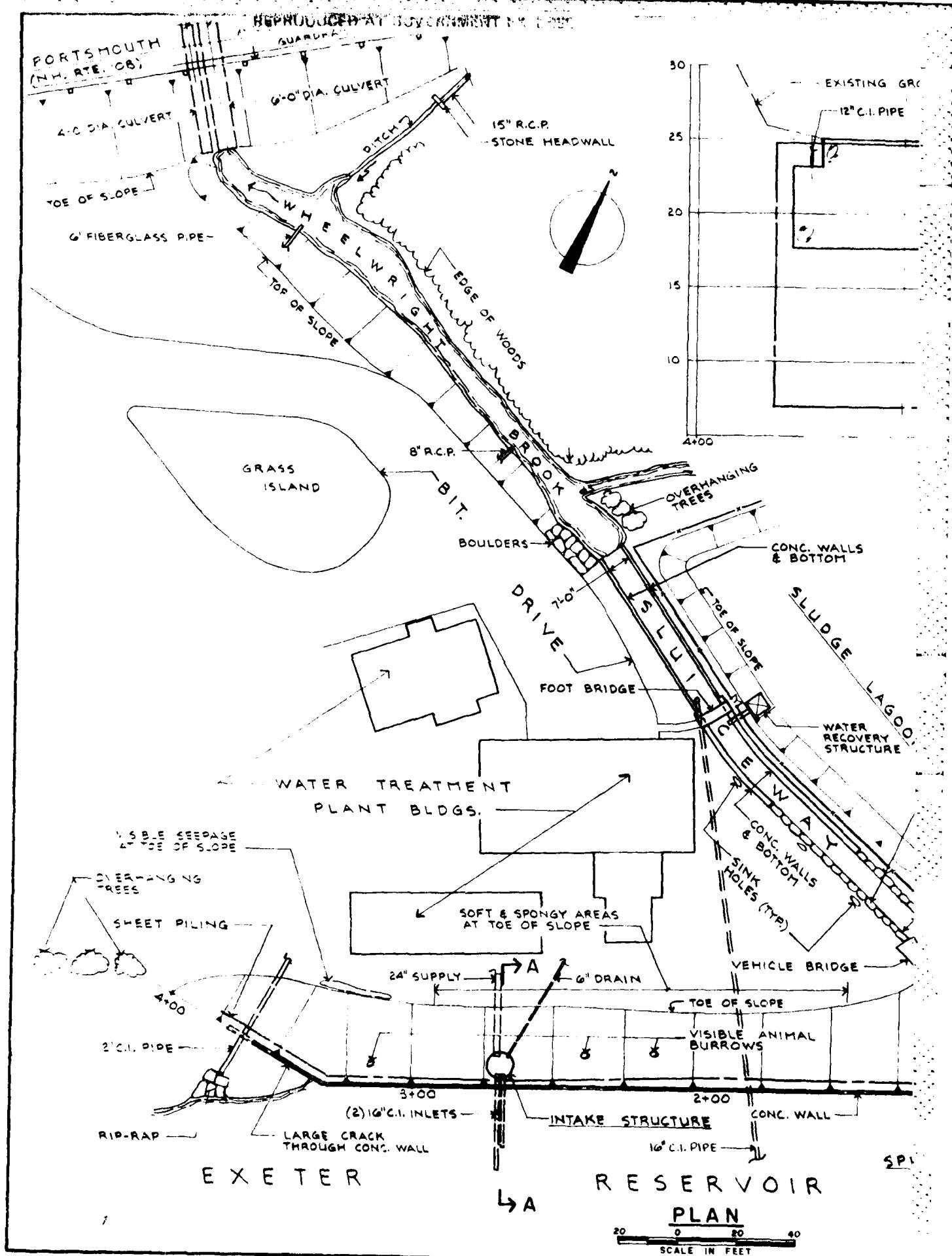
| UNITS | RATED NO. | HP | HEAD FEET | C.F.S. FULL GATE | KW | MAKE |
|-------|-----------|----|-----------|---------------------|----|------|
| — | — | — | — | — | — | — |
| — | — | — | — | — | — | — |
| — | — | — | — | — | — | — |
| — | — | — | — | — | — | — |
| — | — | — | — | — | — | — |
| — | — | — | — | — | — | — |
| — | — | — | — | — | — | — |

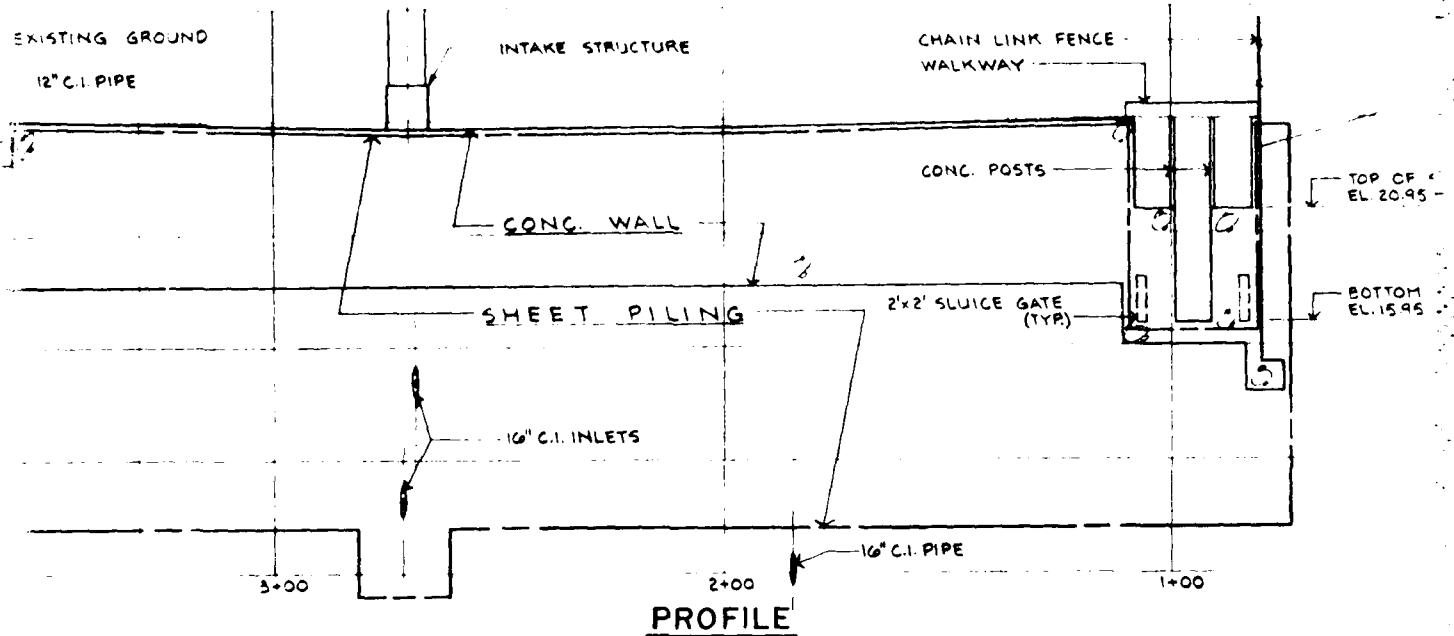
USE Conservation

REMARKS

DATE 9/17/35

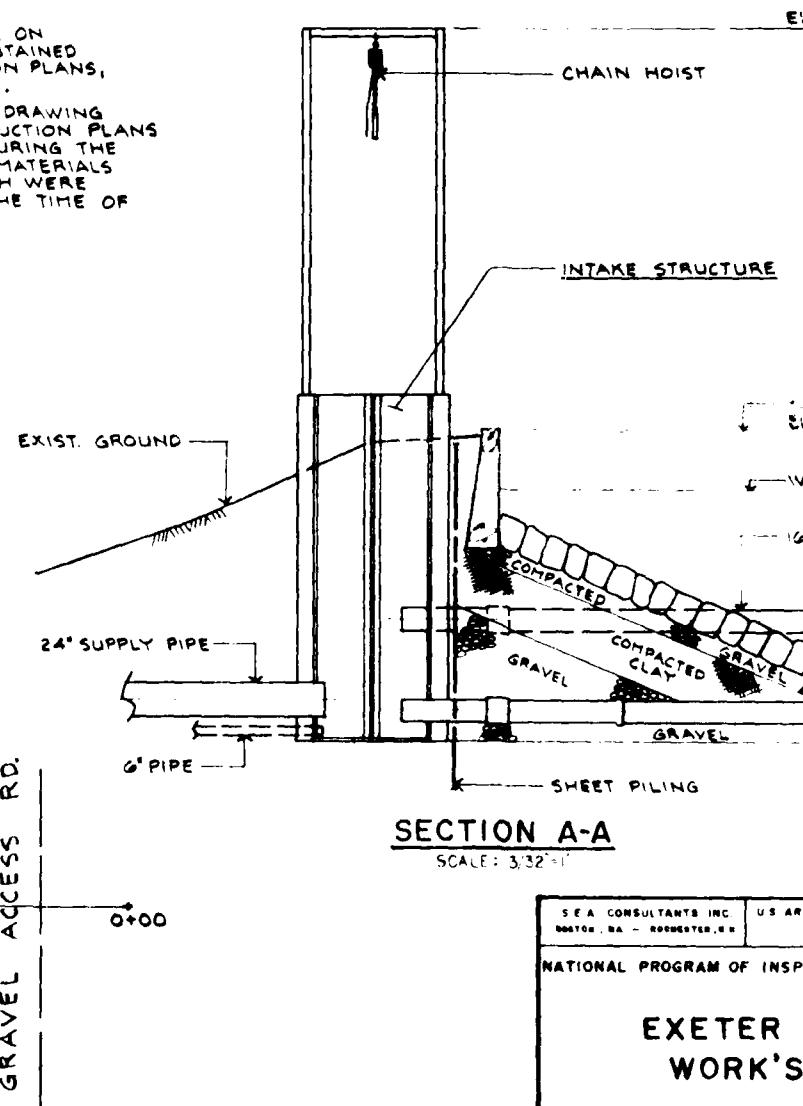
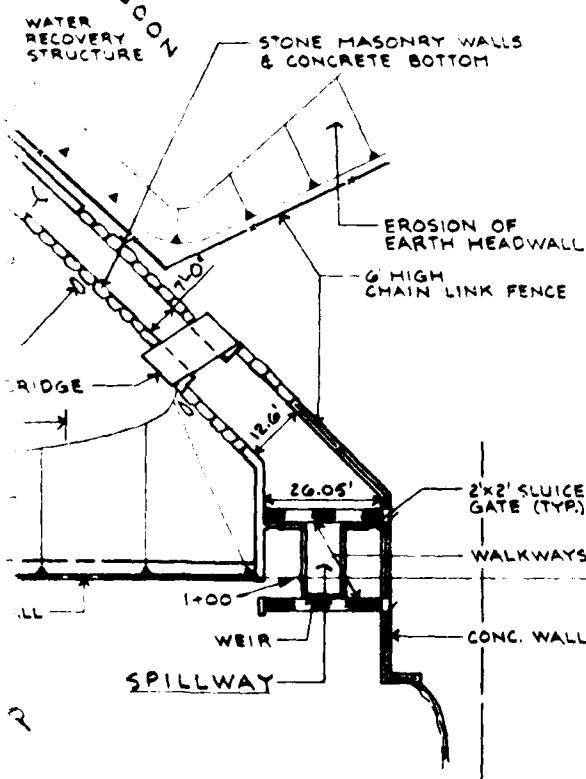
PLANS AND DETAILS



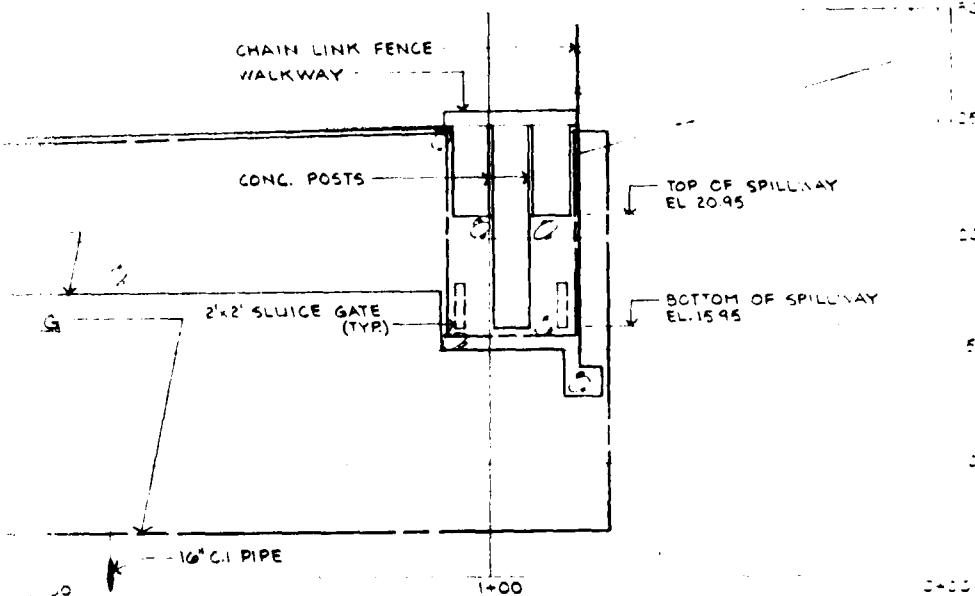


NOTES

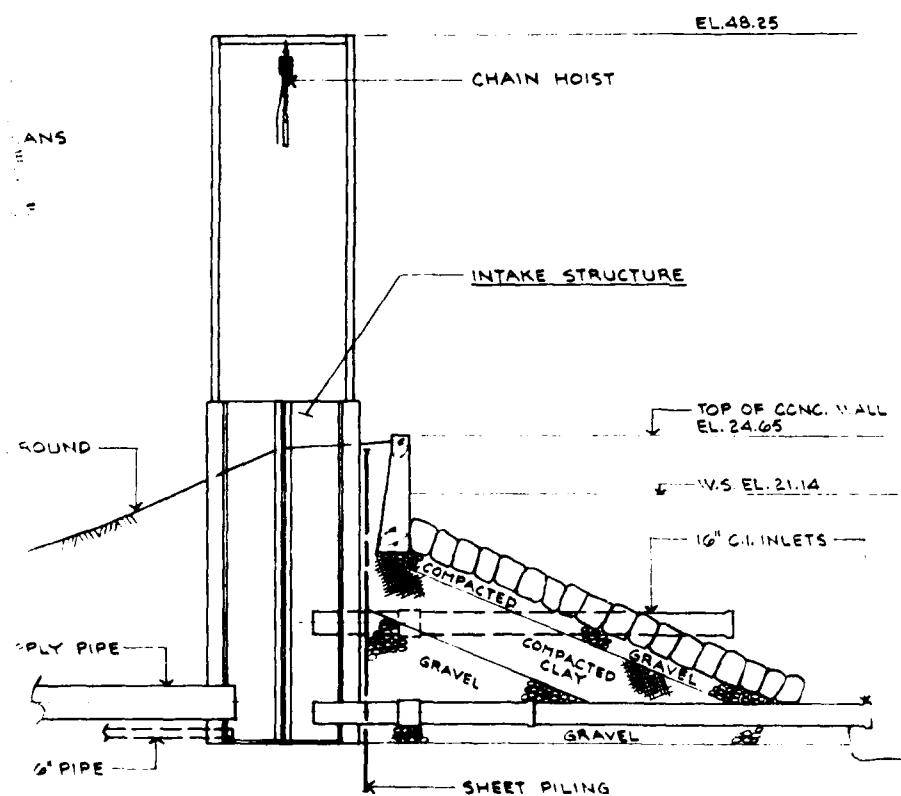
1. THE ELEVATIONS SHOWN ARE BASED ON USGS DATUM FROM INFORMATION OBTAINED FROM THE 1973 DAM RECONSTRUCTION PLANS, BY WESTON & SAMPSON, ENGINEER.
2. THE INFORMATION SHOWN ON THIS DRAWING IS BASED ON THE EXISTING RECONSTRUCTION PLANS AND VISUAL OBSERVATIONS MADE DURING THE FIELD INSPECTION. DIMENSIONS OR MATERIALS INDICATED ON THIS DRAWING WHICH WERE BELOW GRADE OR WATER DURING THE TIME OF INSPECTION WERE NOT VERIFIED.



EXETER
WORK'S



FILE



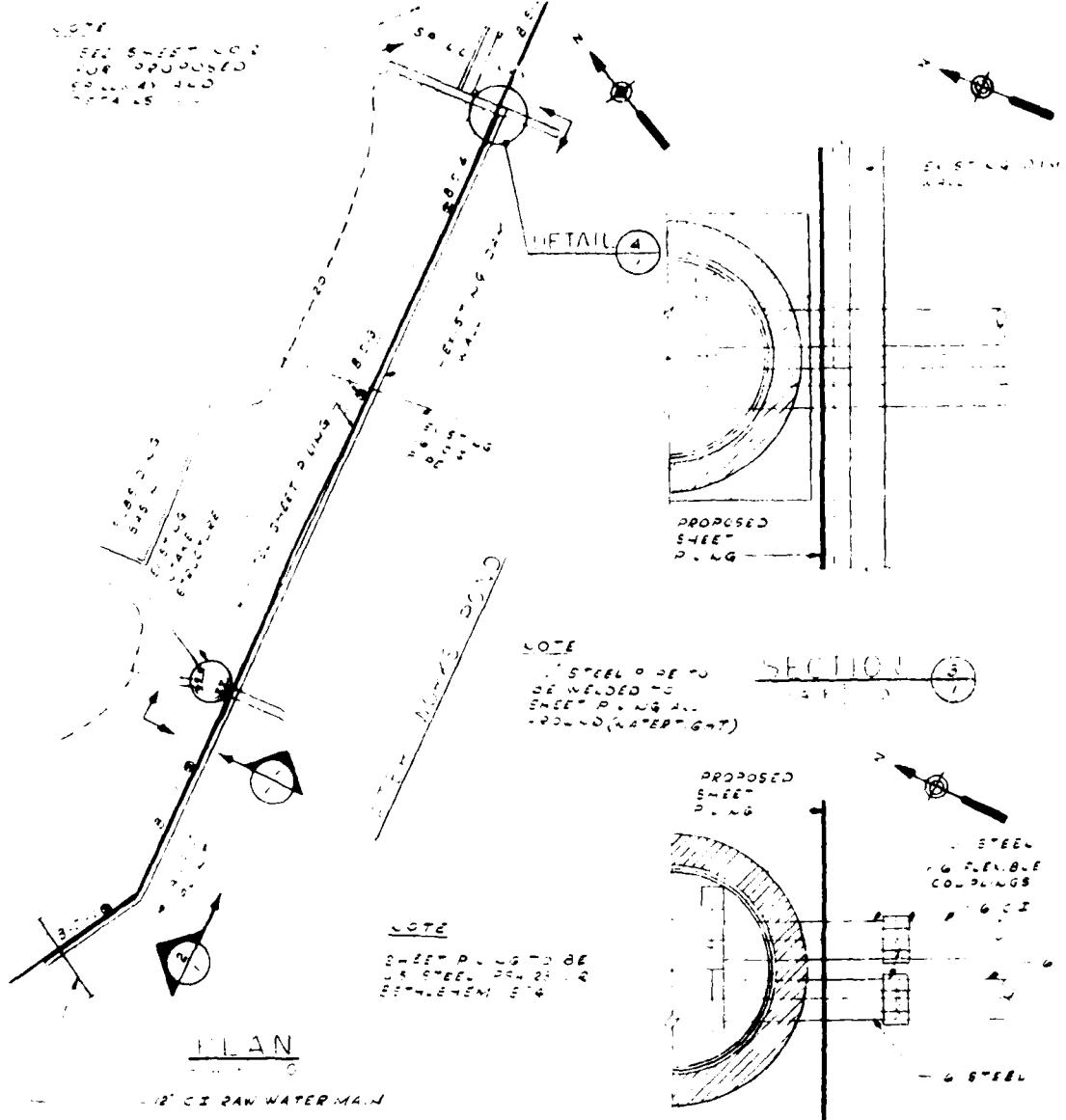
SECTION A-A

SCALE: 3:32"

1-00

| | |
|--|--|
| SEA CONSULTANTS INC. BOSTON, MA - ROCHESTER, NH | U.S. ARMY ENGINEER DIV. NEW ENGLAND CORPS OF ENGINEERS WALTHAM, MA |
| NATIONAL PROGRAM OF INSPECTION OF NON-FED. DAMS | |
| EXETER WATER WORK'S DAM | |
| EXETER, NEW HAMPSHIRE | |
| SCALE AS NOTED DATE NOVEMBER 1976 | |

NOTE
SHEET PILING
TO BE PROPOSED
EL 20.42
EL 20.45



PLAN

- 18" CI RAN WATER MAIN

NOTE

SHEET PILING IN SHEET
PILE WITH CONCRETE
PILE

TOP OF SHEET
PILE

6 CI

E BORING 5-1 E BORING 8-01

TOP OF DAM
@ EL 29.0E BORING 5-3
TOP OF SHEET
PILE @ EL 29.5

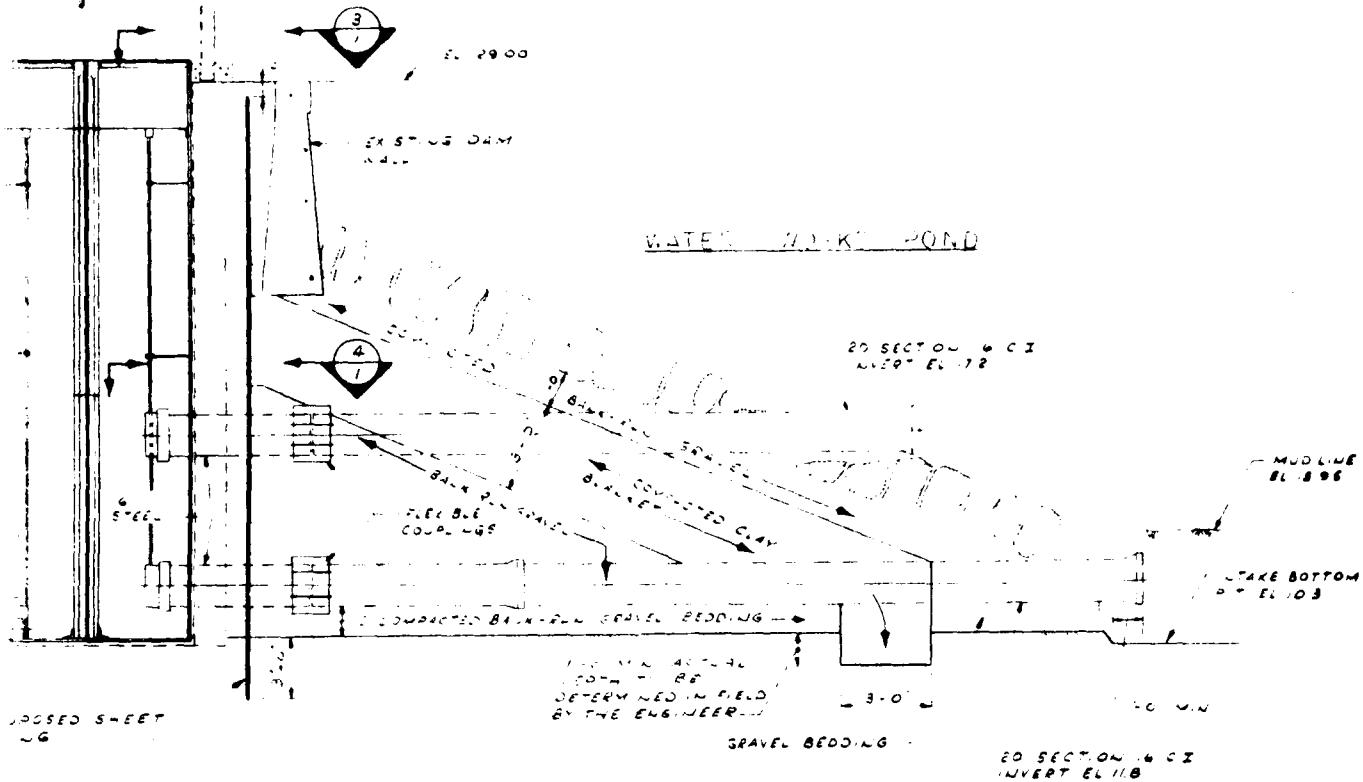
E BORING 5-4

EXISTING
RETAINING
(DEPTH 04)
--- NEW CI

ANGLE
20.42SECTION
2

SHEET PILING LOCATION

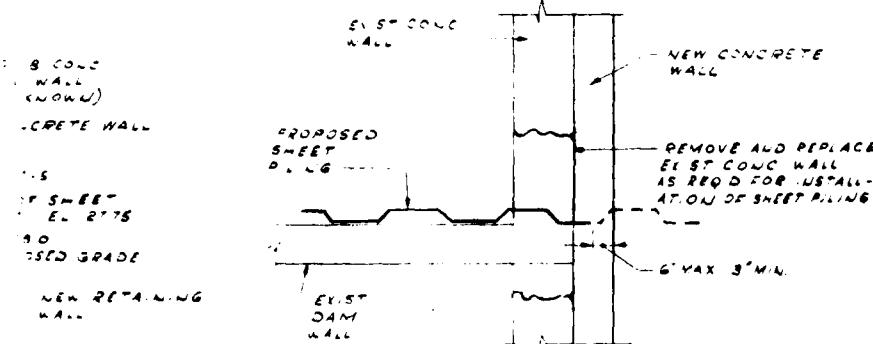
HORIZONTAL
VERT 1.00



SECTION 1/1

INTAKE STRUCTURE RENOVATIONS

SCALE 1/100



NOTES

- BACKFILLING OF ALL EXCAVATED AREAS WITHIN THE LIMITS OF THE DAM EMBANKMENTS SHALL BE THOROUGHLY COMPAKTED IN LAYERS NOT EXCEEDING 6 INCHES IN DEPTH AND SHALL OBTAIN THE PERCENTAGE OF COMPAKCTION STATED ON P-96 OF THE SPECIFICATIONS.
- STEEL PIPES TO BE REPAINTED WITH COATINGS SPECIFIED AFTER ALL WELDING HAS BEEN COMPLETED.
- HANF MIN GRAVEL SHALL BE AS SPECIFIED.
- ALL FITTINGS SHOWN ARE TO BE INSTALLED UNDER THE ORIGINAL WORK. INSTALLATION TO BE DONE AFTER THE SHEET PILING HAS BEEN DRIVEN. HOLES SHALL BE CUT IN THE PILE TO RECEIVE ALL PIPES.

TOWN OF EXETER, NEW HAMPSHIRE

WATER DEPARTMENT

WATER TREATMENT PLANT AND APPURTENANT WORK

DAM RESTORATION

PROPOSED SHEET PILING & DETAILS

WESTON & SAMPSON

ENGINEERS

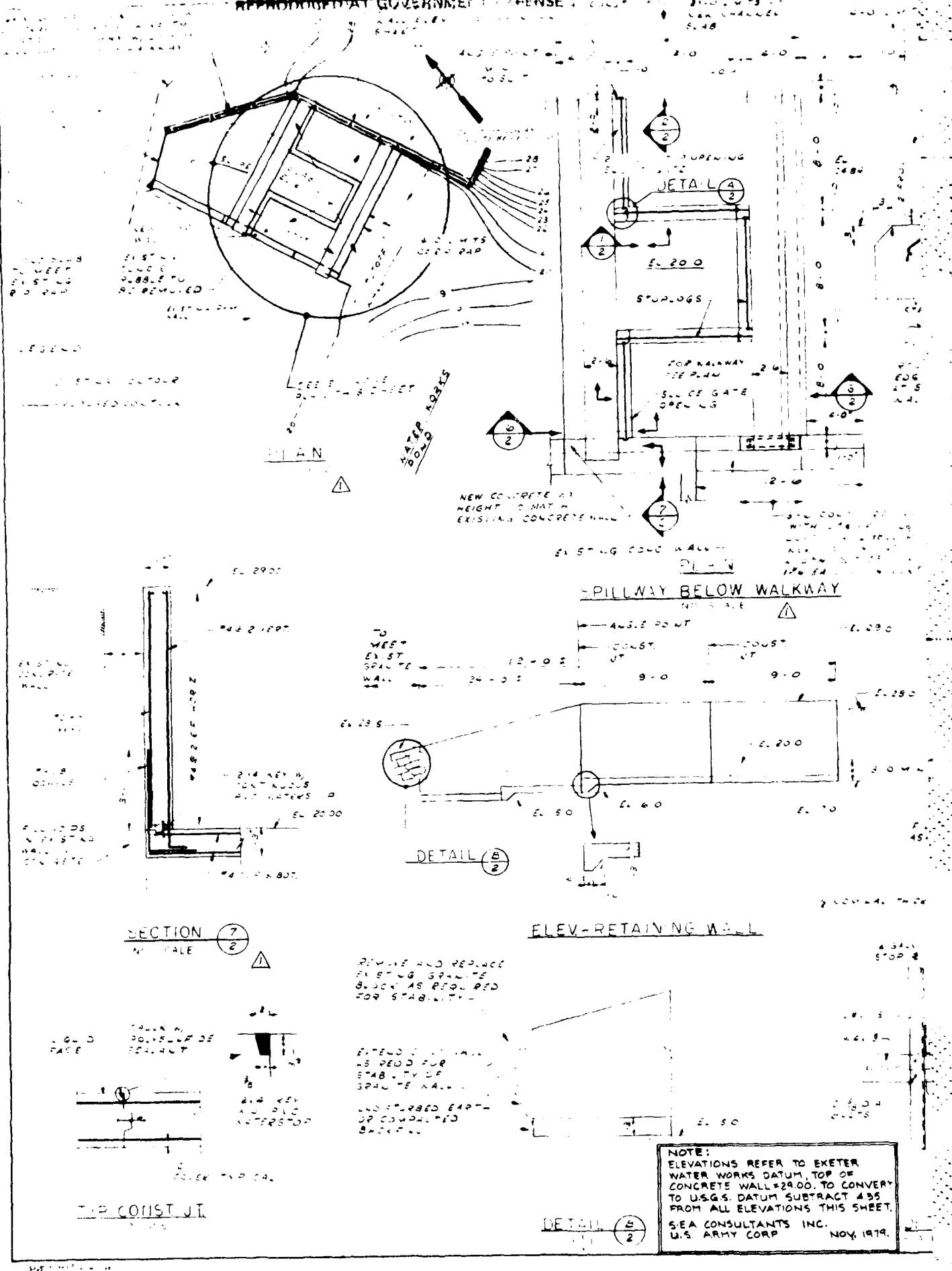
| | | |
|----------------------|---|---|
| DRAWN BY E.P.O. | APPROVED FOR WATER TREATMENT PLANT WESTON & SAMPSON, INC. | 10 HIGH STREET BOSTON, MASS. |
| CHECKED BY E.P.O. | DATE NOV. 1979 | SCALE AS SHOWN DATE OCT. 1973 SHEET 1 OF 2 SHEETS 29-J10 |

| |
|--|
| NOTE: ELEVATIONS REFER TO EXETER WATER WORKS DATUM. TOP OF CONCRETE WALL: 29.00. TO CONVERT TO USGS DATUM SUBTRACT 4.55 FROM ALL ELEVATIONS THIS SHEET. |
| S.E.A. CONSULTANTS INC. U.S. ARMY CORP. |
| NOV. 1979 |

| |
|---|
| ADDED NEW CONCRETE WALL S.U.F. 3/16" 1/4" 1/4" |
| APPROVED FOR WATER TREATMENT PLANT WESTON & SAMPSON, INC. |
| RED PRINT FONTS DATE NOV. 1979 |

APPENDIX AT GOVERNMENT EXPENSE

81-2 - WTS 5
can. 144-166
S. 48



BORING LOGS

BORING REPORT C. L. GUILD DRILLING & BORING CO., 'INC.

MAINSTREET, MASS.

AREA CODE 617
648-3777

TO WESTON & SAMPSON, ENGINEERS DATE. 29 AUGUST 1973
ADDRESS 10 HIGH STREET BOSTON, MASSACHUSETTS
SITE LOCATION PROPOSED DAM RESTORATION EXETER, NEW HAMPSHIRE
REPORT SENT TO ABOVE - ATTN - MR. PERKINS DATE. 29 AUGUST 1973
SAMPLES SENT TO ABOVE - ATTN - MR. PERKINS DATE. 29 AUGUST 1973

BORING LOCATION DRAWING TO BE FURNISHED

BY

OTHERS

B-18

BORING REPORT **C. L. GUILD DRILLING & BORING CO., INC.** BORING REPORT
BRAINTREE, MASS.

TO **WESTON & SAMPSON**
SITE LOCATION **PROPOSED Dam RESTORATION**
SCALE 1" = 8 FT. REFERENCE DATUM FURNISHED BY ABOVE

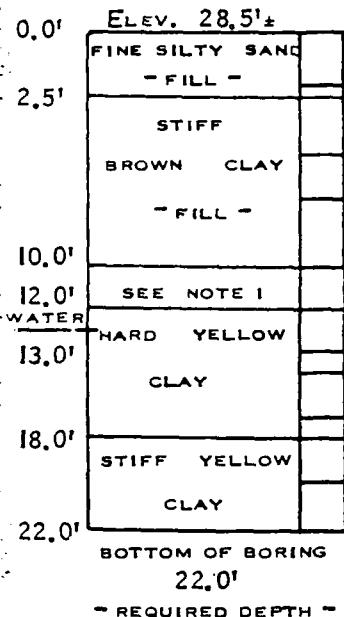
BOSTON, MASSACHUSETTS
EXETER, NEW HAMPSHIRE

BORING NO. **101**

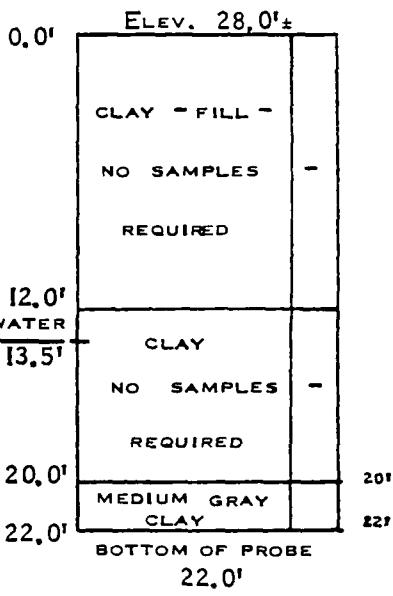
BORING NO.

PROBE
BORING NO. **S-1**

BORING NO.



0' 0" 2 - 3 - 4
2' 0" 2 - 4 - 6 - 5
5' 0" 2 - 4 - 4 - 7
12' 0" 17 - 16 - 25 - 31
14' 0" 8 - 13 - 16 - 18
17' 0" 5 - 6 - 6 - 5



20' 0" 2 - 2 - 2 - 3
22' 0"

NOTE 1 - STIFF YELLOW CLAY TRACE
OF PEAT.

NOTE - USED 2-1/2" CASING & AW RODS

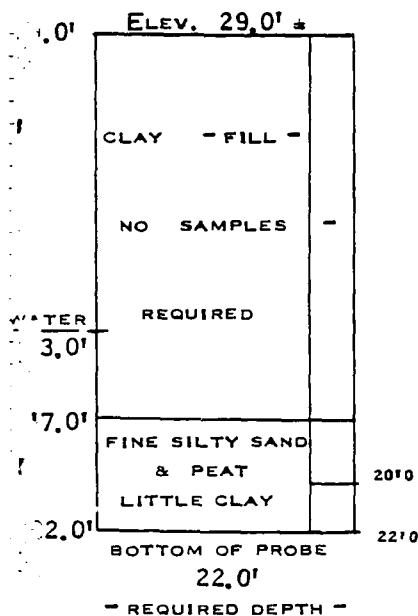
8 - 21 - 73

8 - 21 - 73

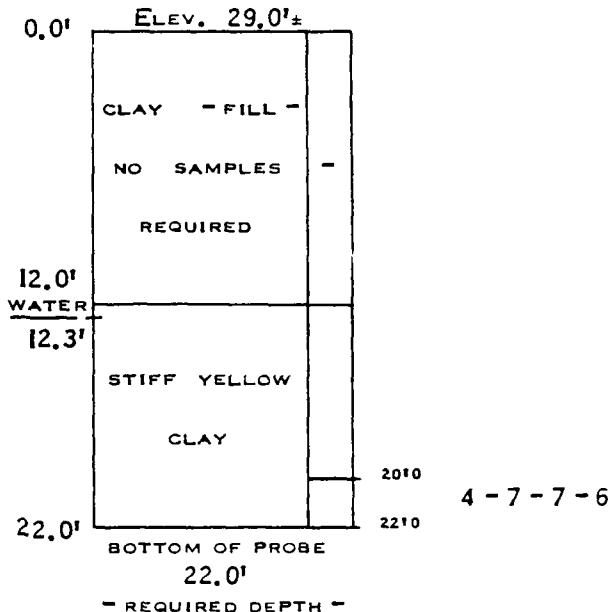
*INDICATES MUD LOST IN THIS LAYER OF SOIL FOOTAGE OF BORING THIS SHEET 44.0'
WATER READING INDICATES SURFACE OF WATER AT COMPLETION OF BORING UNLESS NOTED OTHERWISE. FIGURES IN LOG COLUMN INDICATE
NUMBER OF BLOWS TO DRIVE 2" SPLIT SAMPLER 6 INCHES WITH 140 LB. WEIGHT FALLING 30 INCHES UNLESS OTHERWISE SPECIFIED.
SHEET 2 OF 4 FOREMAN DP CLASSIFICATION BY DP & RYB RB JOB NO. 43056

BORING REPORT **C. L. GUILD DRILLING & BORING CO., INC.** BORING REPORT
BRAINTREE, MASS.

TO **WESTON & SAMPSON** PROPOSED DAM RESTORATION
SITE LOCATION **EXETER, NEW HAMPSHIRE**
SCALE 1" = 8 FT. REFERENCE DATUM FURNISHED BY ABOVE
PROBE BORING NO. **S-3** BORING NO. **S-4** BORING NO.



[-] - [- 2]



4 - 7 - 7 - 6

8 - 22 - 73

8 - 22 - 73

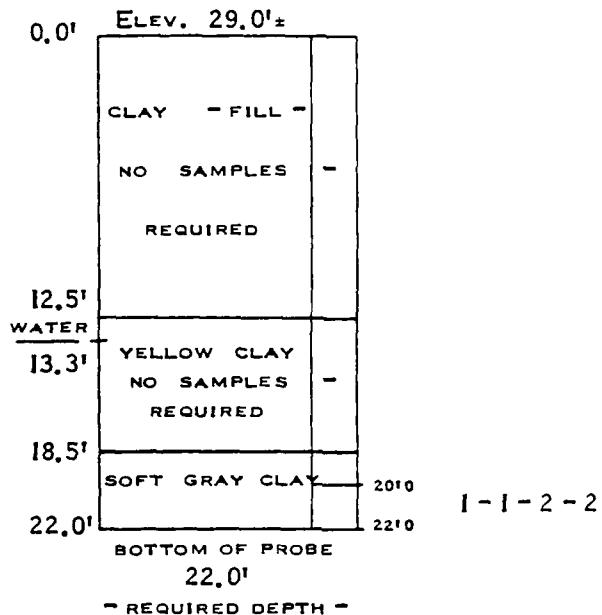
*INDICATES MUD LOST IN THIS LAYER OF SOIL FOOTAGE OF BORING THIS SHEET **44.0'**
WATER READING INDICATES SURFACE OF WATER AT COMPLETION OF BORING UNLESS NOTED OTHERWISE. FIGURES IN LOG COLUMN INDICATE
NUMBER OF BLOWS TO DRIVE 2" SPLIT SAMPLER 6 INCHES WITH 140 LB. WEIGHT FALLING 30 INCHES UNLESS OTHERWISE SPECIFIED.
SHEET **3** OF **4** FOREMAN **DP** CLASSIFICATION BY **DP & RVB** RE JOB NO. **43056**

BORING REPORT **C. L. GUILD DRILLING & BORING CO., INC.** BORING REPO
BRAINTREE, MASS.

TO **WESTON & SAMPSON** BOSTON, MASSACHUSETTS
SITE LOCATION **PROPOSED DAM RESTORATION** EXETER, NEW HAMPSHIRE
SCALE 1" = 8 FT. REFERENCE DATUM FURNISHED BY ABOVE

BORING NO. PROBE BORING NO. **S-5** BORING NO. BORING NO.

BORING NO. BORING NO. BORING NO.



8 - 22 - 73

*INDICATES MUD LOST IN THIS LAYER OF SOIL FOOTAGE OF BORING THIS SHEET 22.0'
WATER READING INDICATES SURFACE OF WATER AT COMPLETION OF BORING UNLESS NOTED OTHERWISE. FIGURES IN LOG COLUMN INDIC
NUMBER OF BLOWS TO DRIVE 2" SPLIT SAMPLER 6 INCHES WITH 140 LB. WEIGHT FALLING 30 INCHES UNLESS OTHERWISE SPECI
SHEET 4 OF 4 FOREMAN DP CLASSIFICATION BY DP - RYB RB JOB NO. 43056

APPENDIX C
SELECTED PHOTOGRAPHS

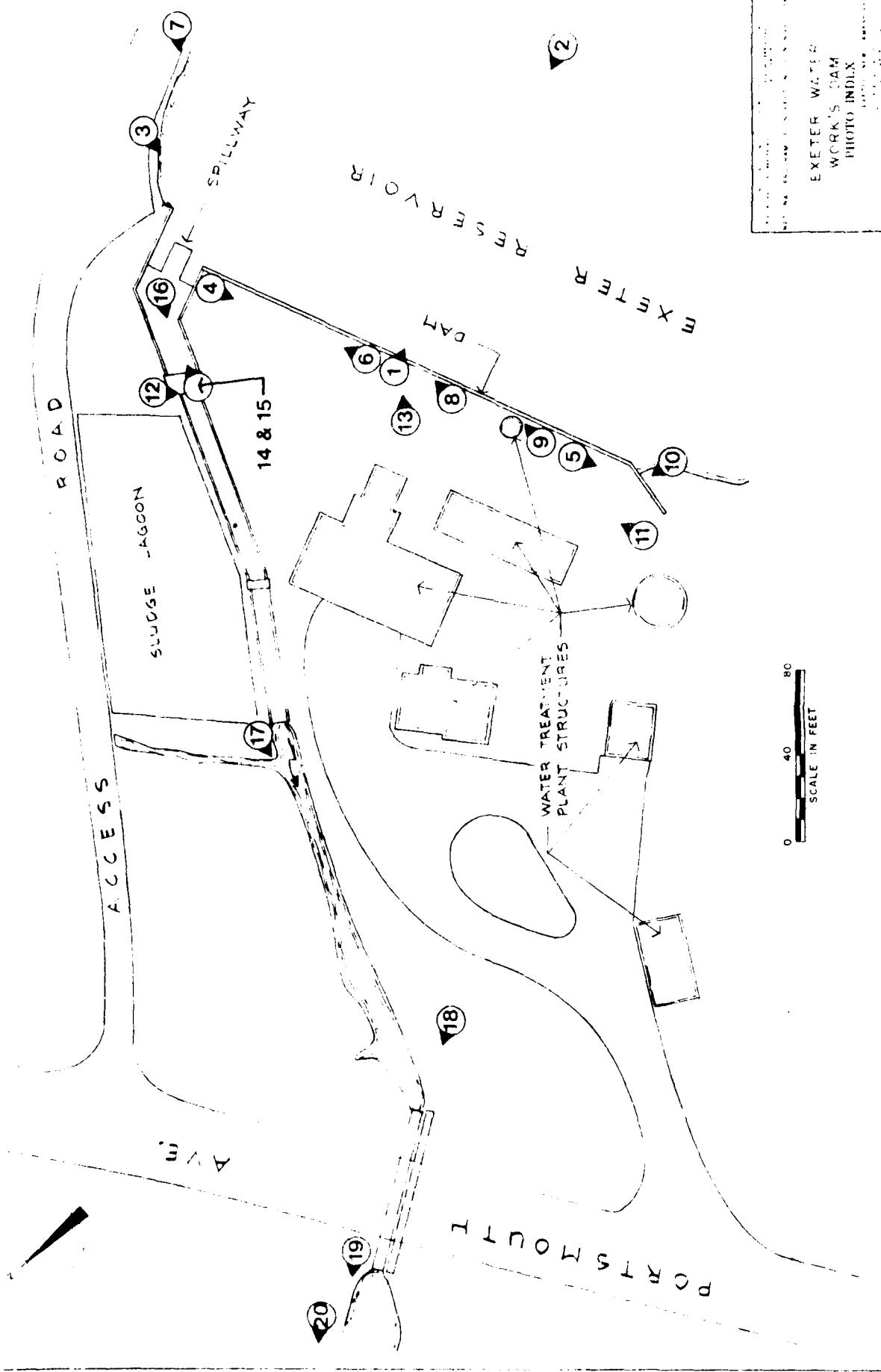




Photo No. 1 - General view of reservoir from center of dam.



Photo No. 2 - General view of dam from reservoir.



Photo No. 5 - View of left abutment from dam.



Photo No. 6 - View of spillway and right abutment from center of dam.

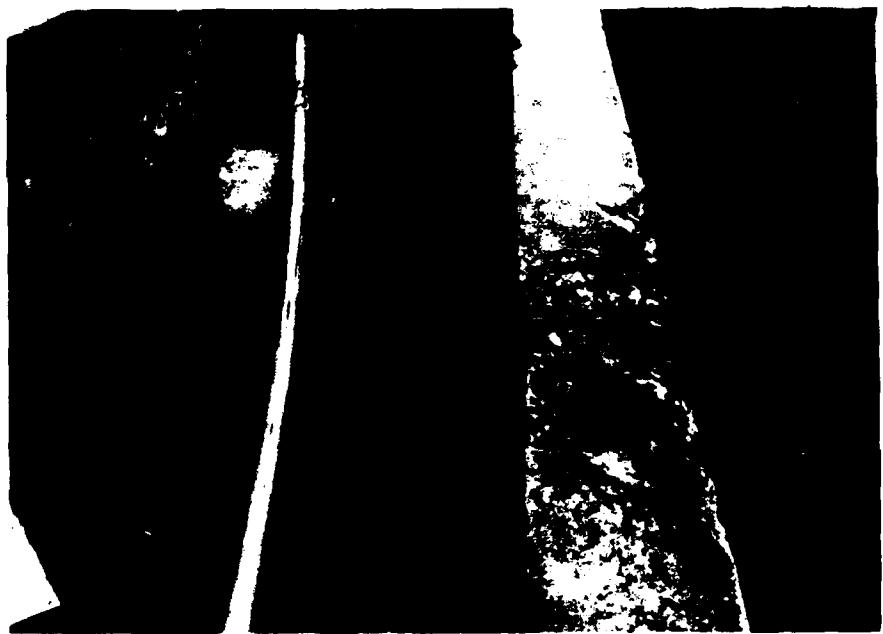


Photo No. 9 - Subsidence of fill along dam crest
at water works inlet structure
(STA. 2+70).

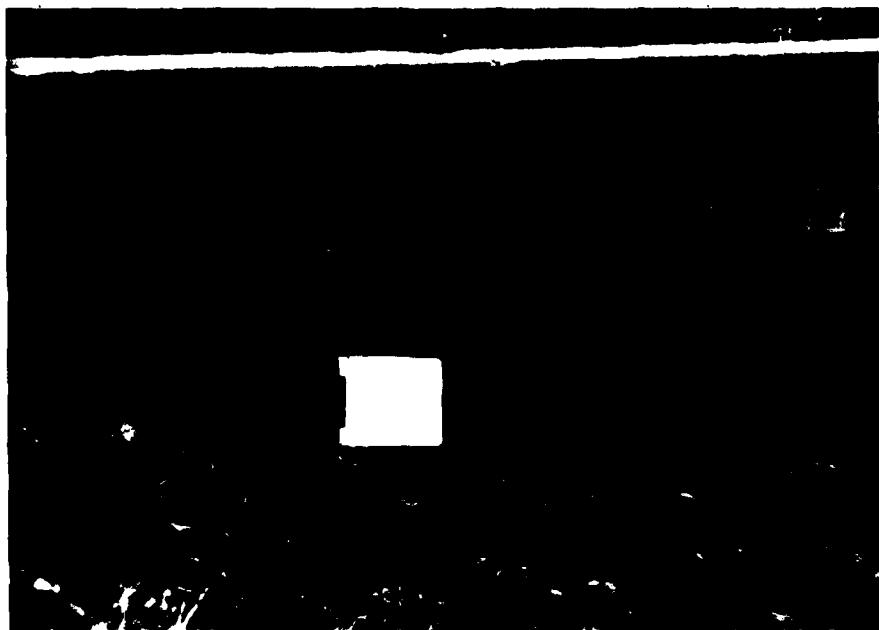


Photo No. 10 - Crack in concrete face wall near
left abutment (STA. 3+39).

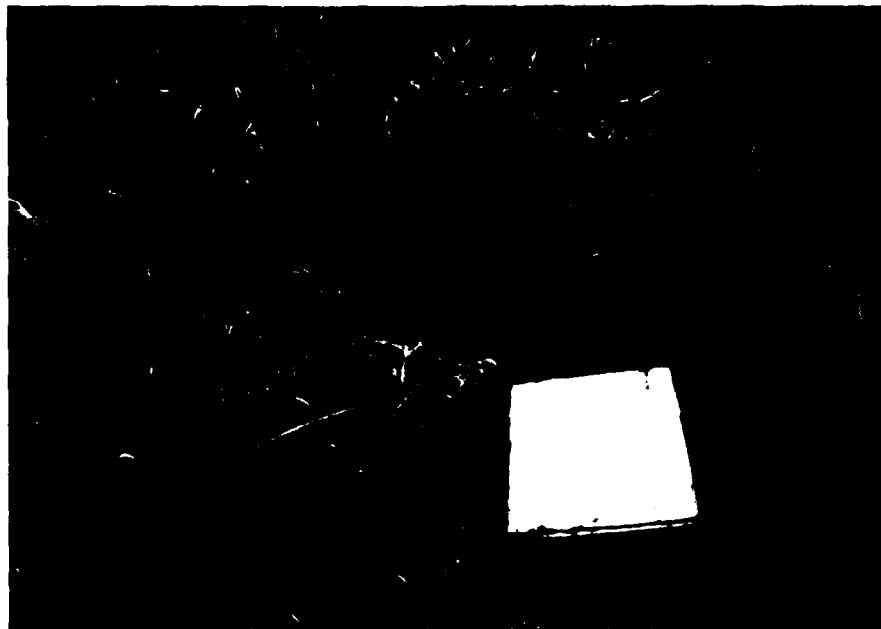


Photo No. 13 - Woodchuck hole in downstream slope
at STA. 2+16 about 5 feet below crest.



Photo No. 14 - View of spillway structure looking
upstream from spillway discharge
channel.

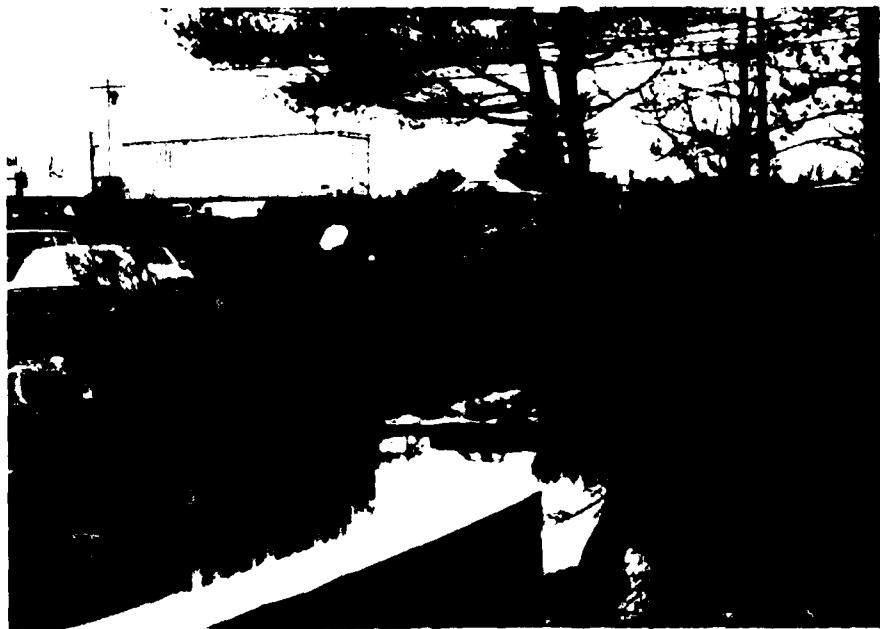


Photo No. 17 - View looking downstream toward roadway culverts from end of spillway discharge channel.



Photo No. 18 - Closeup of roadway culverts (upstream invert).

APPENDIX D
HYDROLOGIC AND HYDRAULIC COMPUTATIONS

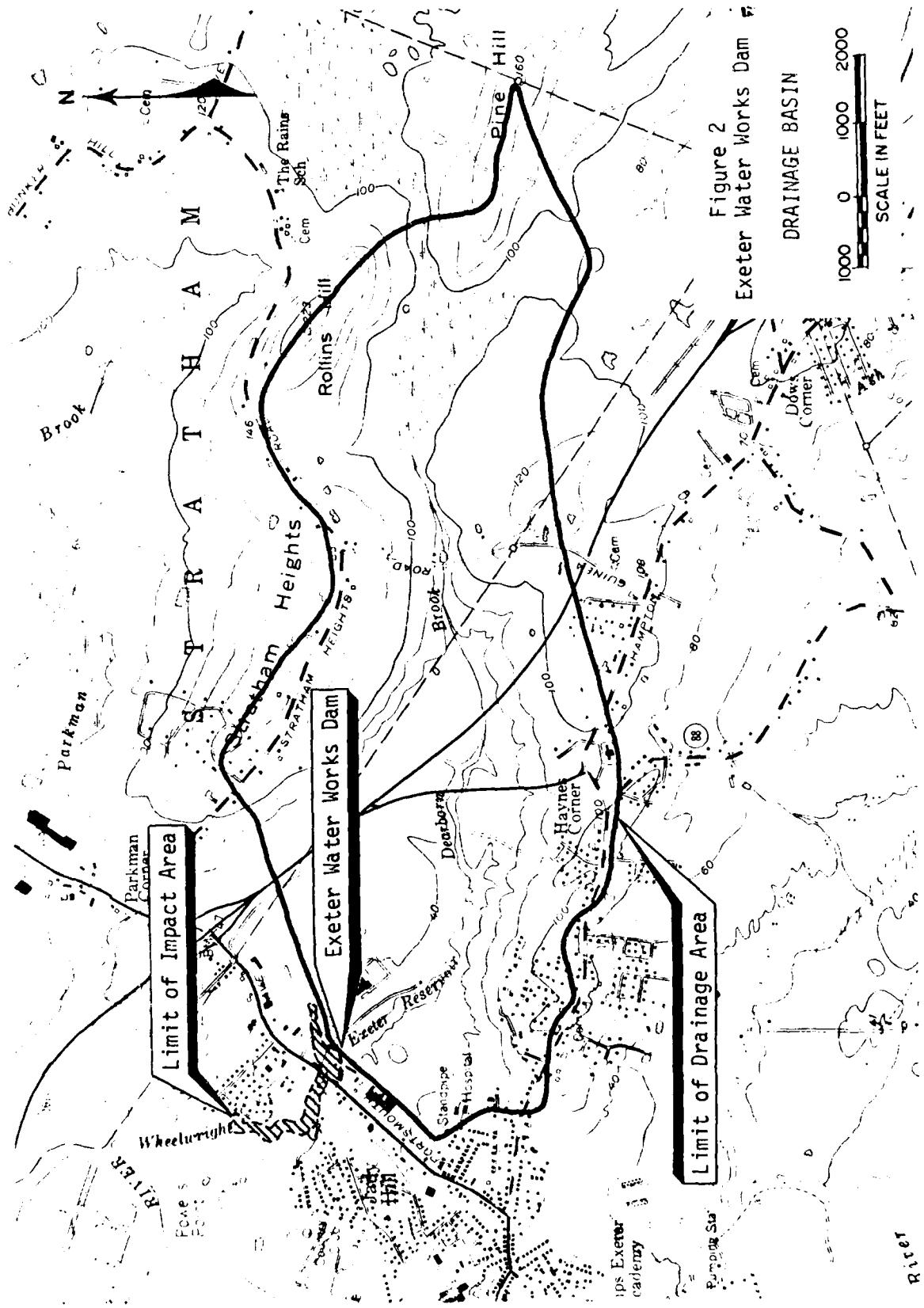


Figure 2
Exeter Water Works Dam

SIEIA CONSULTANTS INC.
ENGINEERS / PLANNERS

BOSTON, MASS.
ROCHESTER, N.H.

CLIENT Inter. Co.
PROJECT Final 1/2 mile line
DETAIL Contingency

Job No. 134-2901 PAGE of 23
COMPTD. BY 2/17 DATE 2/12/69
CK'D. BY KMS DATE 2/12/69

I. Basic Data

A. Drainage Area

1. 1.8 square miles - as defined on U.S.G.S. map and then planimetered
2. drainage area would classify as 10. 1 for estimating MPF Peak Flow Rates

B. Water and Storage Information

1. Size Classification: SMALL (<1000 Acre-ft and 10' crest)

a. Elev. Top of Dam = 29.65 ft
Elev. Pond Bottom = 9.60 ft
(per Drawing - Mud Line)
15.05 ft

b. Estimated surface area of pond at dam crest
≈ 26 acres

c. Storage (Acre-feet)

(1) Total storage = storage between pond bottom and spillway over crest + storage between over crest to dam crest
Storage = $(\frac{2+9.2}{2})(20.95-9.6) + (\frac{26+9.2}{2})(24.65-20.95) = 112$

2. Hazard Potential: HIGH

Failure of dam could result in extensive damage to Exeter Water Treatment Facility and loss of use to most areas of Exeter working class.

N.H. See 103

SIEA CONSULTANTS INC.
ENGINEERS / PLANNERS

BOSTON, MASS.
ROCHESTER, N.H.

CLIENT _____
PROJECT _____
DETAIL _____

Job No. 224-393 **PAGE** 3 - 22
COMPTD. BY _____ **DATE** 1-2-74
CK'D. BY _____ **DATE** _____

3 Storage Information

| Descriptive Information | Elevation,* (ft.) | Surface area* | Volume |
|--|----------------------|---------------|--------|
| Crest of dam (concrete wall) | 24.65 | 26 | 117 |
| Top of stoplogs | 22.95 | 13 | 79 |
| Permanent roadway weir | 20.45 | 9.2 | 52 |
| Invert roadway Gates | 15.45 | 5.1 | 16 |
| Elevation of mud line (per drawing) | 9.60 | 0 | 0 |

* Notes: 1. elevations - U.S.G.S. datum (NGVD)

2. Surface area in acres

3. normal pool elevation taken at

downstream swimming beach and it
was found that the beach was at
the top elevation of the

(b) surface area at the same datum.

4. top elevation of dam is 24.65

5. normal pool elevation at 9.60 ft. above

(c) surface area assumed.

stoplogs + rocks were used to

raise permanent roadway above
normal pool elevation.

and start of the roadway

C. Spurway Information

1. 100 ft. concrete wall with 12' x 12' x 12' concrete

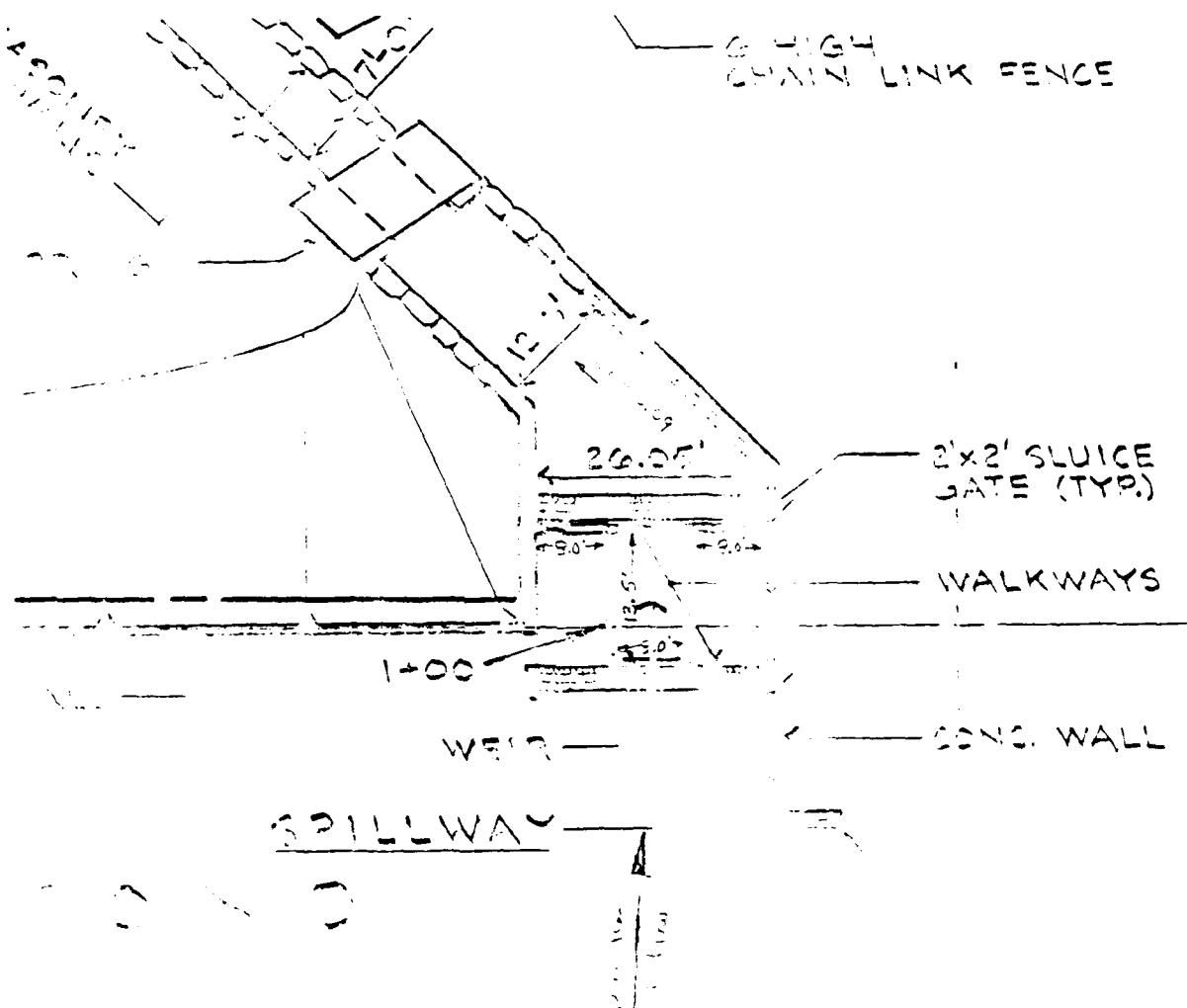
SIEIA CONSULTANTS INC.
ENGINEERS / PLANNERS

BOSTON, MASS.
ROCHESTER, N.H.

CLIENT _____
PROJECT _____
DETAIL _____

Job No. 274-720 PAGE 3 - 22
COMPTD. BY B.M.P. DATE 2-1-71
CK'D. BY B.M.P. DATE

2 Spillway plan



2 have a set of wires which can be snarled
together. If it is assumed that the set of wires, etc., can
have a constant head, then the head
may be found in an ordinary manner
by the formula $H = \frac{1}{2} g (V^2)$

where V = discharge
 g = 32.2 ft. per sec. per sec.

SIEA CONSULTANTS INC.
ENGINEERS / PLANNERS

BOSTON, MASS.
ROCHESTER, N.H.

CLIENT City of ...
PROJECT 13th and ...
DETAIL Bridge ...

Job No. E54-210 **PAGE** 7 12
COMPTD. BY ... 12 **DATE** 2-2-64
CK'D. BY ... 12 **DATE** 2-2-64

L = outside width of bridge
H = height

(b) If page frame supports $L > 2.5H$

$$C = 3.27 + 0.75 \frac{H}{P}$$

where $H = \text{height}$

$P = \text{page width}$

(c) If page width L < support frame width, the standard may be used directly

$$L = L' - 3. N$$

where $L' = \dots$

N = number of panels

H = height

③ will supply the standard for use as an alternative to the estimating formulas

II. Estimate Surface storage or maximum storage

A. Develop Stage-discharge curve for outflow from dam

1. Define sources of inflow

a. Highway - assume stop logs in place (normal operating procedure) and remain closed during the test. Use minimum discharge to 0.0001 cfs

b. At El 23.67 will occur minimum flow during a test period. If possible, move flow from storage area

test to flow area, which would affect the flow downstream. If this is not possible, then the flow will be

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(Standard Handbook for Civil Engineers)

c. at El 24.65 the dam crest will be 20' and
the dam section from dam will be identical to
the road section with 2' shoulder.

2. Railway Outflow

| Elevation | C | Effect L (-) | S (ft) | Q (ft) |
|-----------|-------|--------------|--------|--------|
| 22.95 | — | — | 0.0 | 0.0 |
| 23.0 | 3.273 | 50.2 | 0.35 | ..3 |
| 24.0 | 3.330 | — | 1.35 | .30 |
| 25.0 | 3.387 | — | 1.15 | 4.92 |
| 26.0 | 3.444 | — | 3.05 | 9.21 |
| 27.0 | 3.501 | — | 7.05 | 14.80 |
| 28.0 | 3.559 | — | 5.05 | 20.80 |
| 29.0 | 3.616 | — | 6.05 | 23.00 |
| 30.0 | 3.673 | — | 7.05 | 24.50 |

3. Flow by passing railway, ~ 30' crest

| Elevation | C | L (-) | S (-) | Q (-) |
|-----------|------|-------|-------|-------|
| 23.65 | — | — | — | — |
| 24.0 | 2.60 | 3 | 0.33 | 3.00 |
| 25.0 | — | 23 | 0.31 | 12 |
| 26.0 | — | 42 | 0.29 | 12.8 |
| 27.0 | — | 50 | 0.27 | 11.2 |
| 28.0 | — | 72 | 0.25 | 10.0 |
| 29.0 | — | 74 | 0.23 | 9.0 |
| 30.0 | — | 74 | 0.21 | 8.0 |

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DETAIL Building Calc

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4. Free side dam (damming 20' max. 10' = 3' crest)

| Elevation | C | L | S | D |
|-----------|------|-----|------|------|
| 24.65 | — | — | — | — |
| 25.0 | 2.54 | 222 | 1.35 | 117 |
| 26.0 | 2.66 | 269 | 1.35 | 1120 |
| 27.0 | 2.65 | 272 | 2.35 | 2600 |
| 28.0 | 2.66 | 275 | 2.25 | 4490 |
| 29.0 | 2.68 | 274 | 1.35 | 6710 |
| 30.0 | 2.74 | 273 | 5.50 | 9390 |

5. Total outflow

| Elevation | G | G | Q | Q |
|-----------|--------|------|------|--------|
| Spillway | by sec | cu m | cu m | TOTAL |
| 22.75 | 0.0 | 0.0 | 0.0 | 0.0 |
| 23.0 | 1.8 | 0.0 | 0.0 | 1.8 |
| 24.0 | 180 | 3.0 | 0.0 | 183 |
| 25.0 | 499 | 92 | 1.7 | 705 |
| 26.0 | 921 | 333 | 1120 | 2429 |
| 27.0 | 1430 | 932 | 2600 | 4162 |
| 28.0 | 2030 | 1690 | 4490 | 5210 |
| 29.0 | 2700 | 2370 | 6710 | 1780 |
| 30.0 | 3450 | 3150 | 9390 | 15,990 |

Information in table shown graphically in
Figure 1

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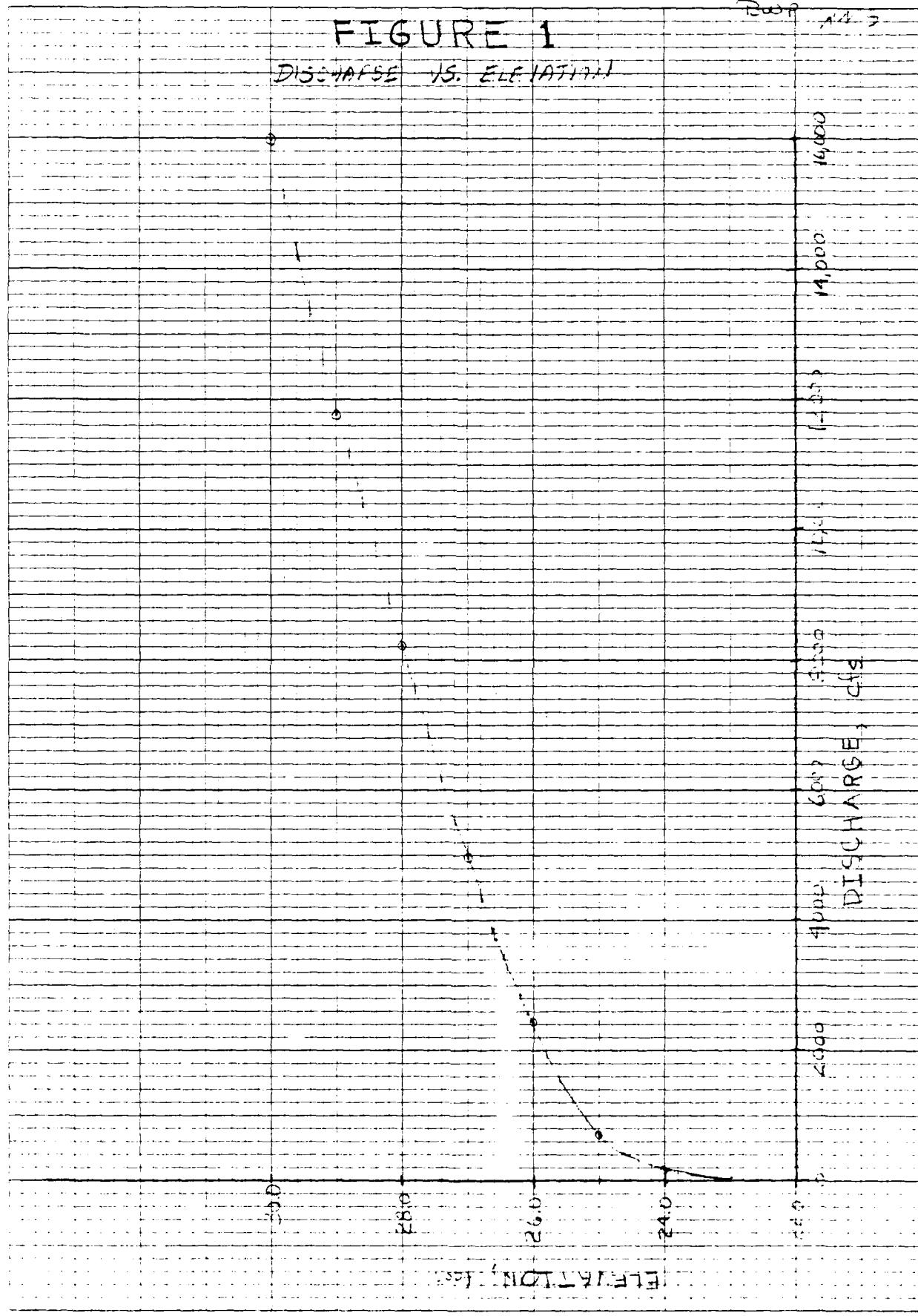
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PROJECT Everett Water Works Dam

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DETAIL Hydrologic Calcs

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3. Effect of surcharge storage on Max Prob. Inflow

1. Pertinent Data

- (1) Drainage area = 1.8 square miles
- (2) characteristics of basin - rolling
- (3) test flood - PMF (small size and high hazard)
Follow Army Corps' procedure

2. STEP 1: Determine Peak Inflow (Q_{pi}) from Guide Curves

a. extrapolating from Guide Curve the maximum probable flood was estimated at 2150 cfs/sq.m.

$$\therefore \text{Max Prob Flood} = (2150 \text{ cfs/sq.m}) (1.3 \text{ sq.m}) \\ = 3870 \text{ cfs}$$

3. STEP 2: Determine Surcharge Height to max Q_{pi} , $STOR$, and Q_{p2}

a. from Figure 1 determine surcharge height to pass $Q_{pi} = 3870 \text{ cfs}$

Surcharge Elev. = 20.65 feet

Spillway stoplog Elev. = 22.95 feet
3.70 feet

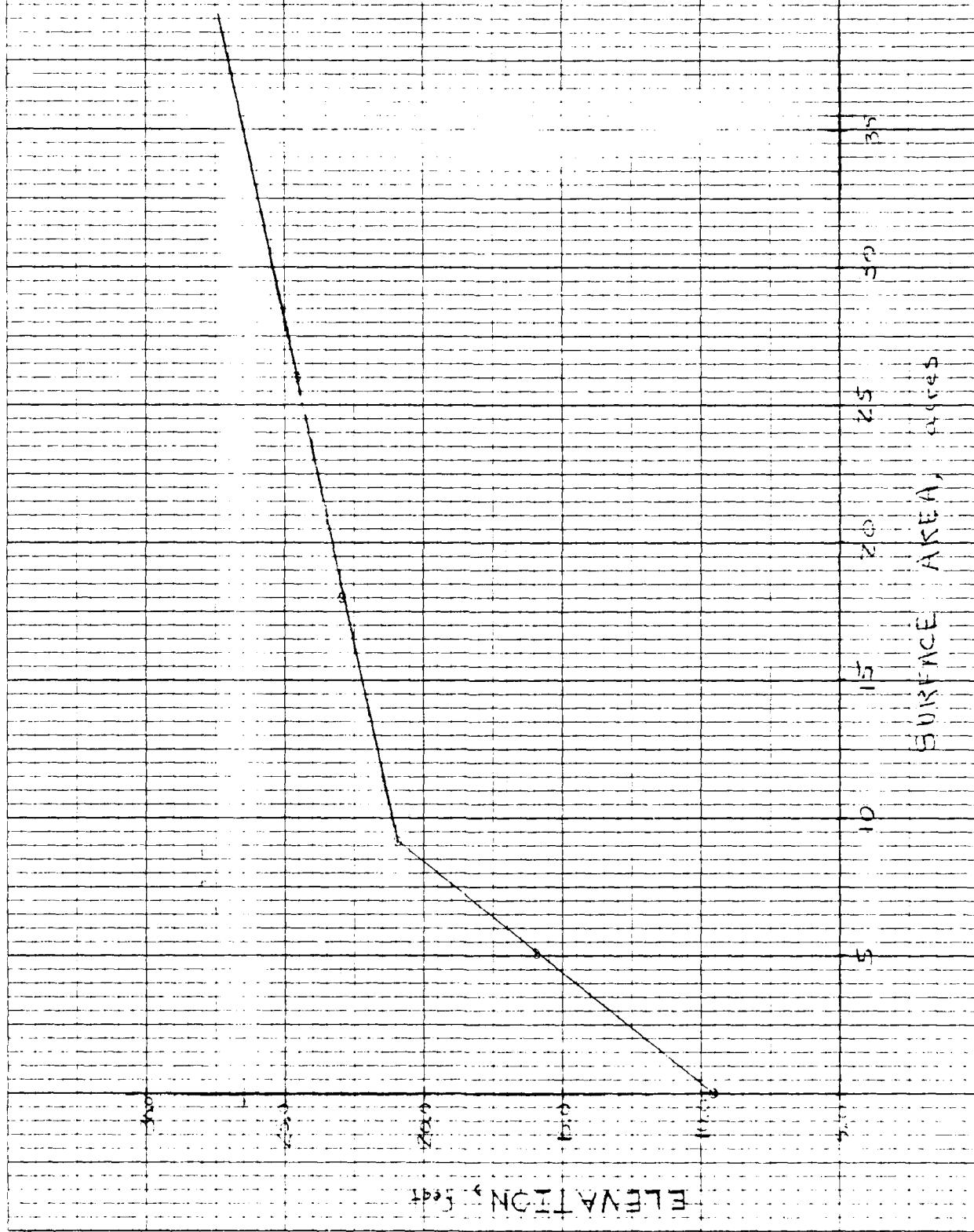
b. determine Volume of surcharge ($STOR_1$) in inches of runoff

(1) use average pond area between spillway crest elev and surcharge elev (see Figure 2) to determine storage.

$$STOR_1 = \frac{\text{Volume of storage (in. x in. x in.)}}{\text{drainage area}} \\ = \frac{\left(\frac{18+36.0}{2} \text{ acres}\right) (3.70 \text{ feet}) (12 \text{ inches/foot})}{(1.8 \text{ sq.m}) (640 \text{ acre/sq.m})}$$

FIGURE 2

SURFACE AREA VS. ELEVATION



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$$STOR_1 = 1.04 \text{ inches}$$

c. determine Q_{P2}

$$\begin{aligned} Q_{P2} &= Q_{P1} \left(1 - \frac{STOR_1}{19}\right) \\ &= (3870 \text{ cfs}) \left(1 - \frac{1.04}{19}\right) \\ &= 3653 \text{ cfs} \end{aligned}$$

4. STEP 3: Determine Surcharge height and $STOR_2$
To Pass Q_{P2} and then Q_{P3}

a. from Figure 1 determine surcharge height to pass

$$Q_{P2} = 3658 \text{ fs}$$

$$\begin{aligned} \text{Surcharge elev} &= 26.55 \\ \text{Highway - stoplog elev} &= \underline{22.95} \text{ feet} \\ &\quad 3.60 \text{ feet} \end{aligned}$$

b. determine $STOR_2$

$$\begin{aligned} STOR_2 &= \frac{(35.5 + 13 \text{ acres})(3.60 \text{ feet})(12 \text{ inches/feet})}{(1.8 \text{ sq.mi})(640 \text{ acres/sq.mi})} \\ &= 1.00 \text{ inches} \end{aligned}$$

c. Average $STOR_1$ and $STOR_2$

$$\begin{aligned} STOR_{AVG\ 1-2} &= \frac{STOR_1 + STOR_2}{2} \\ &= \underline{1.04 \text{ in}} + \underline{1.00 \text{ in}} \end{aligned}$$

$$STOR_{AVG\ 1-2} = 1.02 \text{ inches}$$

d. determine Q_{P3}

$$Q_{P3} = (3870 \text{ cfs}) \left(1 - \frac{1.02}{19}\right)$$

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$$Q_{P3} = 3662 \text{ cfs}$$

5. STEP 4: Determine surcharge height for Q_{P3} and $STOR_3$

a. from Figure 1 surcharge height for $Q_{P3} = 3662 \text{ cfs}$

$$\begin{aligned} \text{Surcharge elev} &\approx 26.55 \text{ feet} \\ \text{Spillway-stoplog elev} &= \frac{22.45}{3.60} \text{ feet} \\ &= 6.20 \text{ feet} \end{aligned}$$

b. determine $STOR_3$

$$\begin{aligned} STOR_3 &= \frac{(18 + 35.5 \text{ acres}) (3.60 \text{ ft}) (1.00 \text{ ft})}{(1.85 \text{ sg.m.})(640 \text{ acre/sg.m.})} \\ &= 1.00 \text{ inches} \end{aligned}$$

c. determine $STOR_{AVG}$

$$\begin{aligned} STOR_{AVG} &= \frac{1.00 \text{ in} + 1.02 \text{ in}}{2} \\ &= 1.01 \text{ inches} \end{aligned}$$

d. determine Q_{P4}

$$\begin{aligned} Q_{P4} &= (3870 \text{ cfs}) \left(1 - \frac{1.01}{19}\right) \\ &= 3664 \text{ cfs} \end{aligned}$$

6. STEP 5: Determine surcharge height for Q_{P4} and $STOR_4$

a. from Figure 1 surcharge height for $Q_{P4} = 3664 \text{ cfs}$

$$\begin{aligned} \text{Surcharge elev} &\approx 26.55 \text{ feet} \\ \text{Spillway-stoplog elev} &= \frac{22.95}{3.60} \text{ feet} \\ &= 6.32 \text{ feet} \end{aligned}$$

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b. determine STOR₄

$$\text{STOR}_4 = \frac{(18 + 35.5 \text{ acres})}{2} \left(3.60 \text{ in.} \right) \left(\frac{12 \text{ in.}}{1.3 \text{ sq. mi.}} \right) \left(\frac{640 \text{ acres}}{1 \text{ sq. mi.}} \right)$$
$$= 1.00 \text{ inches}$$

c. determine STOR AVG

$$\text{STOR AVG} = \frac{1.00 \text{ in.} + 1.01 \text{ in.}}{2}$$
$$= 1.005 \text{ inches}$$

d. determine Q_{ps}

$$Q_{ps} = (3870 \text{ cfs}) \left(1 - \frac{1.005}{19} \right)$$
$$= 3665 \text{ cfs}$$

STOR₅ will also = 1.00 and with the process STOR_# and STOR AVG converging very slowly, however Q has changed only slightly. Therefore, will accept
 $Q = 3665 \text{ cfs}$

6 In Conclusion

a Test flood discharge = 3665 cfs and will overtop dam crest by 1.9 feet

b Spillway Capacity - Step log. = 24.2

(1) at elev 23.67 $Q = 100 \text{ cfs}$
(point at main flow bypass - spillway)

(2) at elev 24.65 $Q = 375 \text{ cfs}$
(dam crest)

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(3) at elev 26.55 feet $Q = 1190 \text{ cfs}$
(Test flood)

c Spillway Capacity - stoplogs removed

(1) at elev 23.67 $Q = 795 \text{ cfs}$

(2) at elev 24.65 $Q = 1275 \text{ cfs}$

(3) at elev. 26.55 feet $Q = 2475 \text{ cfs}$

d Spillway Capacity - stoplogs removed - service gates open

(1) at elev 23.67 $Q = 385 \text{ cfs}$

(2) at elev 24.65 $Q = 1330 \text{ cfs}$

(3) at elev 26.55 $Q = 2595 \text{ cfs}$

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PROJECT East Water Works Dam

DETAIL More Hydrologic Calcs

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III Using "Rule of Thumbs" Guidance for Estimating
Downstream Dam Failure Hydrographs examine
Impact of dam failure

1. Pertinent Data

a. Failure occurs when reservoir level at crest of
dam elev = 24.65 ft.

b. Storage at crest elevation estimated to be
approximately 122 acre-ft.

A. REACH 1

1. STEP 1: Determine reservoir storage at time of
failure
from previous calcs = 117 acre-ft

2. STEP 2: Determine Peak Failure Outflow (Q_{p1})

$$Q_{p1} = \theta/27 W_b \sqrt{g} Y_o^{3/2}$$

Where: W_b = Reach width (use 40% of
total length)

$$= (0.40)(248 \text{ feet})$$

$$\approx 99 \text{ feet}$$

Y_o = Water height from river bed
to pool level at failure

$$\text{pool level} = 24.65 -$$

$$\text{elev. end of channel} = \frac{24.65 - 15.05}{15.05}$$

$$Y_o \approx 15 \text{ feet}$$

$$Q_{p1} = \theta/27, 99 \text{ feet}, (32.27)^{1/2} (15)^{3/2}$$

$$\approx 9,670 \text{ cfs}$$

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3. STEP 3: Prepare Stage-discharge curve → Figure

Since reach is controlled by culverts beneath Portsmouth Avenue, the stage-discharge curve will represent culvert discharge (normal discharge and then choked flow) to elevation 18.7 feet. At this point, flow over the road will occur. The stage-discharge data have been summarized in Figure 3

1. Data:

- 1 Length of reach ≈ 400 ft
- 2 Culverts -

| <u>SIZE</u> | <u>Slope</u> | <u>Len²</u> |
|----------------------|--------------|------------------------|
| 6' \varnothing CMP | 0.009 | ≈ 100 ft |
| 4' \varnothing CMP | 0.011 | ≈ 100 ft |

4. STEP 4: Estimate Reach Outflow

2 Determine Stage for $Q_{p1} = 14,500$ cfs from Figure 3 and volume in reach

(1) Stage = 22.4 feet (Δ depth = 22.4' - 3.6' = 18.8' - 3.6' = 15.2')

(2) Volume in reach

using trapezoidal shaped channel cross-section



$$X\text{-Area} = 0.5 (18.8' \cdot 460 \text{ ft}) \approx 4465 \text{ ft}^2$$

$$\text{Volume} = (400 \text{ ft}) (4465 \text{ ft}^2) \left(\frac{1 \text{ acre}}{43,560 \text{ ft}^2} \right)$$

$$\approx 41.0 \text{ acre-ft}$$

Since $V < \frac{S}{2}$ reach length is 200 ft

5. Determining Q_{p2} (7 sec -)

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$$Q_{P2}(\text{TRIAL}) = Q_{P1} \left(1 - \frac{V}{S}\right)$$
$$= (9,670 \text{ cfs}) \left(1 - \frac{41 \text{ ac-ft}}{117 \text{ ac-ft}}\right)$$

$$Q_{P2}(\text{TRIAL}) \approx 6,280 \text{ cfs}$$

c. Compute V_2 using $Q_{P2}(\text{TRIAL})$

From Figure 3 determine Stage $\approx Q_{P2}(\text{TRIAL})$

$$\text{Stage} \approx 21.8 \text{ ft. } (21.8 - 3.6 = 18.2 \text{ ft})$$
$$X\text{-Area} \approx 0.5(18.2)(330 + 15) \approx 3,595 \text{ ft}^2$$

$$V_2 = (\text{reach length})(X\text{-Area})$$
$$= (400 \text{ ft})(3,595 \text{ ft}^2) \left(\frac{1 \text{ acre}}{43,560 \text{ ft}^2}\right)$$
$$\approx 33 \text{ acre-ft}$$

d. Average V_1 and V_2 and Compute Q_{P2}

$$(1) V_{avg} = \frac{V_1 + V_2}{2}$$
$$= \frac{41.0 \text{ acre-ft} + 33.0 \text{ acre-ft}}{2}$$

$$V_{avg} = 37.0 \text{ acre-ft}$$

$$(2) Q_{P2} = Q_{P1} \left(1 - \frac{V_{avg}}{S}\right)$$
$$= (9,670 \text{ cfs}) \left(1 - \frac{37 \text{ ac-ft}}{117 \text{ ac-ft}}\right)$$

$$Q_{P2} \approx 6,610 \text{ cfs}$$

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B. REACH 2

1. STEP 3 Prepare stage-discharge curve for Reach 2

a. Present Data

- (1) Reach length ≈ 300
- (2) Slope ≈ 0.001
- (3) Manning's "n" = 0.06
- (4) Channel shape - trapezoidal
- (5) base width $\approx 15'$

b. See Figure 3 for curve

2. STEP 4

a. Determine stage for $Q_{P2} = 6,610 \text{ cfs}$ from Figure 3 and volume in reach

$$(1) \text{ stage} = 16.6 \text{ feet } (C_r = 16.6' - 2.8' = 13.8')$$

(2) Volume in reach

$$V_1 = \frac{(300 \text{ ft}) [(0.5)(13.8 \text{ ft})(300 \text{ ft} + 15 \text{ ft})]}{43,560 \text{ ft}^3/\text{acre}} \\ = 15.0 \text{ acre-ft}$$

$$V < \frac{S}{2} \text{ reach length ok}$$

b. Determine $Q_{P3(\text{trial})}$

$$Q_{P3(\text{trial})} = Q_{P2} \left(1 - \frac{V_1}{S} \right) \\ = (6610 \text{ cfs}) \left(1 - \frac{15.0}{117} \right)$$

$$Q_{P3(\text{trial})} = 5760 \text{ cfs}$$

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PROJECT Fire Dept Water Main
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C compute V_2 using $Q_{P3}(T=5)$

From Figure 3 determine stage for $Q_{P3}(T=5)$

$$\text{Stage} \approx 15.3 \text{ feet} \quad (5 \text{ ft} = 15.3' - 15')$$

$$\begin{aligned} X\text{-Area} &\approx (0.5)(13.0 \text{ ft}) (285 \text{ ft} + 15 \text{ ft}) \\ &\approx 1950 \text{ ft}^2 \end{aligned}$$

$$V_2 = \frac{(300 \text{ ft}) (1950 \text{ ft}^2)}{43,560 \text{ ft}^2/\text{acre}}$$

$$= 13.4 \text{ acre-ft}$$

d. Average V_1 and V_2 and compute Q_{P3}

$$\begin{aligned} (1) V_{\text{avg}} &= \frac{15.0 \text{ acre-ft} + 13.4 \text{ acre-ft}}{2} \\ &= 13.4 \text{ acre-ft} \end{aligned}$$

$$\begin{aligned} (2) Q_{P3} &= Q_{P2} \left(1 - \frac{V_{\text{avg}}}{5}\right) \\ &= (6,610 \text{ cfs}) \left(1 - \frac{13.4}{117}\right) \\ &\approx 5,810 \text{ cfs} \end{aligned}$$

C REACH 3

1. STEP 3 Prepare stage-discharge curve for Reach

a Pertinent Data

(1) Reach length = 450 feet

(2) Slope ≈ 0.0002

(3) Manning's "n" = 0.08

(4) Channel shape - trapezoidal

(5) base width $\approx 430'$

b see Figure 3 for curve

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DETAIL Hydrologic Calcs

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2. STEP 4

a. Determine stage for Q_{P4} = 5810 cfs from Figure
and volume in reach

$$(1) \text{Stage} = 9.8 \text{ feet} \quad (\text{Depth} = 9.8' - 2.7' = 7.1')$$

(2) Volume in reach

$$V_1 = \frac{(450 \text{ ft}) [0.5 (7.1 \text{ ft} (3-0) - 530)]}{13,560 \text{ ft}^2/\text{acres}}$$

$$= 31.9 \text{ acre-ft}$$

$V_1 \leq \frac{1}{2} \text{ Trunk length}$

b. Determine $Q_{P4}(\text{Trunk})$

$$\begin{aligned} Q_{P4(\text{Trunk})} &= Q_{P3} \left(1 - \frac{V_1}{s}\right) \\ &= 5,810 \text{ cfs} \left(1 - \frac{31.9}{117}\right) \end{aligned}$$

$$Q_{P4(\text{Trunk})} \approx 4,230 \text{ cfs}$$

c. Compute V_2 using $Q_{P4(\text{Trunk})}$

From Figure 3 determine stage for $Q_{P4(\text{Trunk})}$

$$\text{Stage} \approx 8.8 \text{ feet} \quad (\text{Depth} = 8.8' - 2.7' = 6.1')$$

$$X\text{-Area} = (0.5) (6.1 \text{ ft} \times 340 \text{ ft} + 5.5 \text{ ft}^2)$$

$$\approx 2608 \text{ ft}^2$$

$$V_2 = \frac{450 \text{ ft} \times 2608 \text{ ft}^2}{13,560 \text{ ft}^2/\text{acres}}$$

$$\approx 26.9 \text{ acre-ft}$$

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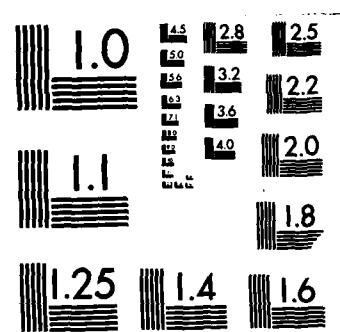
NATIONAL PROGRAM FOR INSPECTION OF NON-FEDERAL DAM
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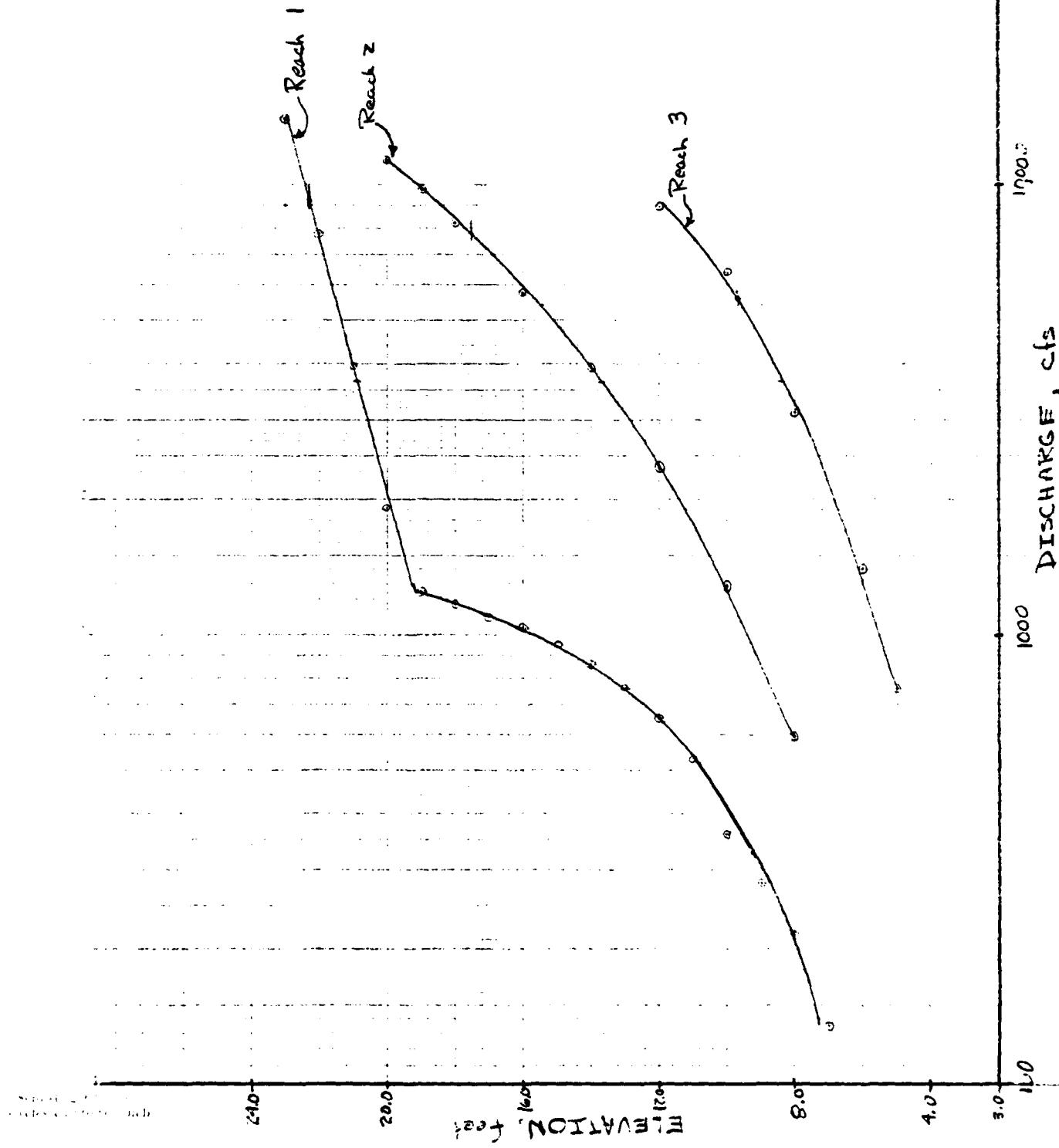
d. Average V_1 and V_2 and compute Q_{P4}

$$(1) V_{avg} = \frac{31.9 \text{ acre-ft} + 26.9 \text{ acre-ft}}{2} \\ = 29.4 \text{ acre-ft}$$

$$(2) Q_{P4} = Q_{P3} \left(1 - \frac{V_{avg}}{S} \right) \\ = (5,810 \text{ cfs}) \left(1 - \frac{29.4}{117} \right)$$

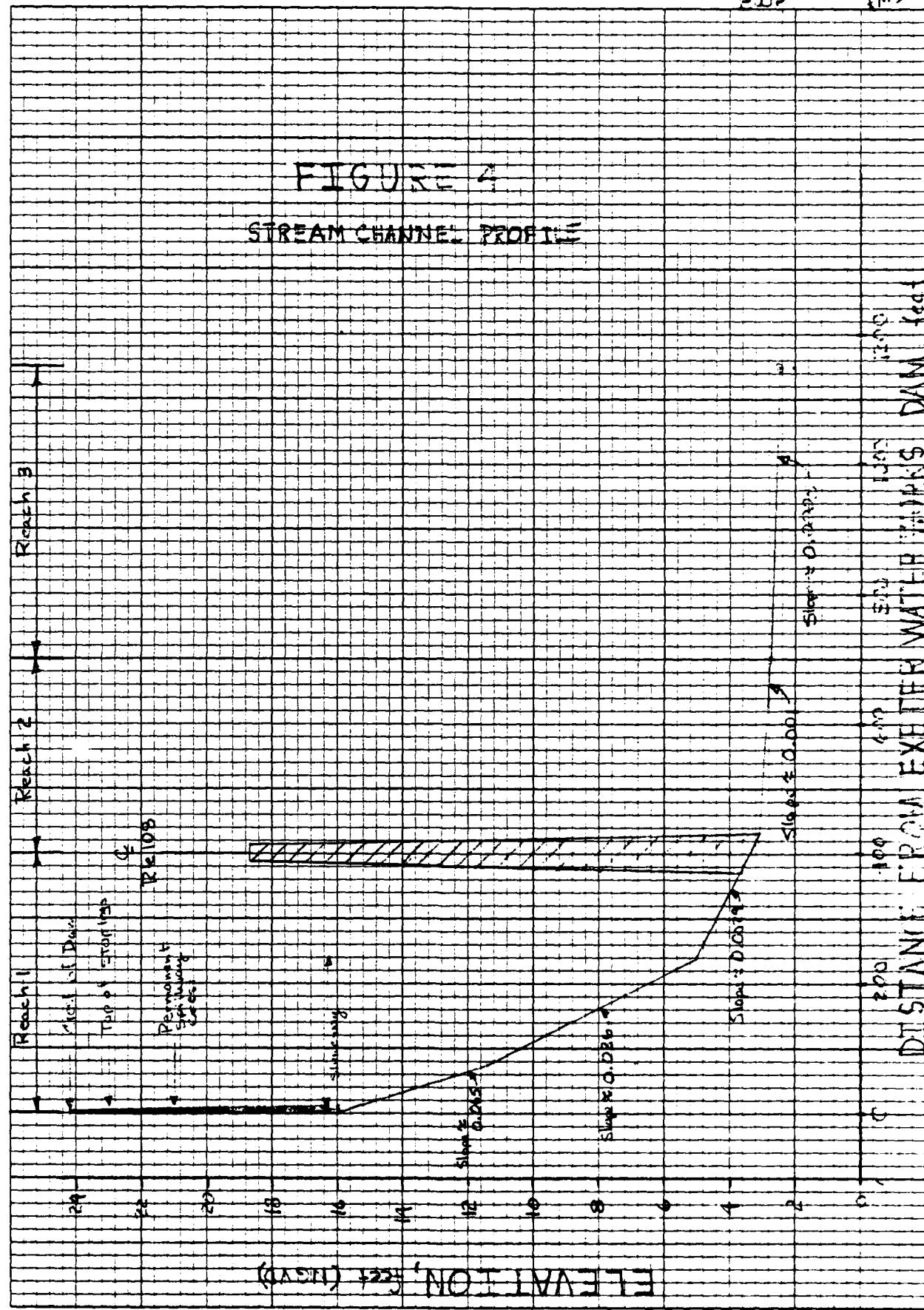
$$Q_{P4} \approx 4,350 \text{ cfs}$$

FIGURE 3
DISCHARGE VS. ELEVATION



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VMSFIGURE 4
STREAM CHANNEL PROFILE

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